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OPTICAL TRUTHS

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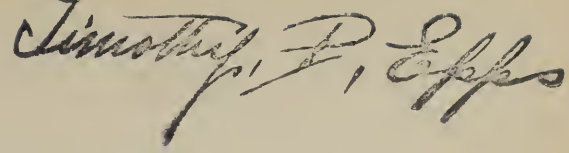

OPTICAL TRUTHS

Second Edition

ILLUSTRATED

By CHARLES McCORMICK, M. D.
President McCormick Neurological College
The First Non-Sectarian Medical School
CHICAGO

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INTRODUCTION.

In the practice of ophthalmology one of the essentials is a general knowledge of the nervous system, what it is, whence it cometh, and whither it goeth.

It is simply a complete telegraph system, intimately connecting every portion of the anatomy.

In structure it is a series of tubular membranes containing in a minute and continuous stream, matter identical with the brain substance, through which electrical energy is transmitted.

This energy is of two kinds, galvanic and faradic. The first is generated by the digestive organs, and is constant; the second, is an intermittent current generated by molecular friction throughout the body.

The nervous system is divided into two classes, the cerebro-spinal or animal, and the sympathetic or organic.

There are two currents of nerve force. The afferent, from the peripheral parts to the nerve centers, and the efferent, from the nerve centers to the peripheral parts.

The brain is the chief nerve center. All force is sent there, and thence distributed in every direction and in such proportions as conditions require. To do this the brain gives off twelve pairs of cranial nerves and the spinal cord, the latter being the grand trunk line which supplies the minor centers in the body.

In normal physiological conditions the distribution of nerve force is proportionate to the capacity for supply, and Nature has so arranged that the brain contains a reserve stock for emergencies. Were it not for this wise provision the suspension or decrease in capacity of the source of supply would, surely and speedily, result in death.

In youth the quantity of reserve force, as well as the ca-

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pacity for supply is greater, hence the more speedy recovery from injuries and ills. Extraordinary drain upon the nerve supply can be endured without discomfort, because of these conditions. When, however, the reserve supply is exhausted, the demand is made directly upon the capacity of the machinery and trouble follows.

Any abnormal physiological condition, or functional demand which requires more than the normal proportion of nerve force in one direction, will have evil effects upon other functions as soon as the reserve is reduced below the safety line. One of these is the intense thought associated with grief, joy, fear, anger and other emotions, because the demand is directly upon the chief source of supply.

In this connection it is interesting to note by experiment, the effect of thought upon the various functions. The phenomena of blushing, turning pale, etc., are illustrations of the influence of thought upon the nerves which control the circulation of blood.

The influence of the mind upon the body is being recognized by the medical colleges of today, and psychology is one of the special branches taught. The Faith Healers find the basis for their work in the same proposition, coupled with a fanatical belief that they are especially endowed by God.

Each case which presents itself to the ophthalmologist has individual peculiarities, and only a thorough knowledge of elementary principles of anatomy, physiology, neurology, physics, psychology and mathematics will enable the practitioner to meet them with credit to himself and comfort to his patients. He must also cultivate his common sense, and look for the simplest way out of any difficulties which may arise.

In the following pages the author endeavors to give information, accompanied by practical reasons for each proposition, and trusts it will be of service to all into whose hands it may come.

This, second edition, is issued in response to continued demands since the first one was exhausted two years ago.

LIGHT AND REFRACTION.

Elementary Laws Which Reveal the Breadth and Comprehensiveness of Nature.

Everything, to our minds, educated by finite things, must have a beginning—and an end. Therefore, let us imagine that there was a beginning to this universe; that it is the effect of a cause. It is a well-settled proposition, except among fanatics, that we shall never conceive in what form, if any, that cause existed or exists, other than as we refer to it as an

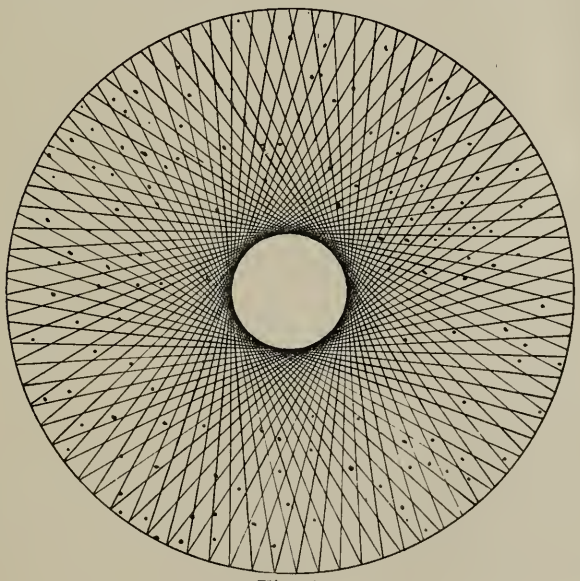


Fig. 1

infinite mind, instead of as a person. To me the law, as exhibited in its effects, is far more magnificent than an individual could be possibly.

It is our privilege to study the laws, if we will, independently of accepted authorities; and when we see how far some have strayed from the facts, which came to light after their theories were exploited, we are admonished to avail ourselves of the privilege.

As the refraction of light is one of the primary laws by which ophthalmology is expounded in this work, it is necessary to define light and I choose the following hypothesis as a beginning:

Let Fig. 1 represent the universe, the large central field the sun, the small dots the planets. In the operation of the chemical laws combination and disintegration, attraction and repulsion, form and motion were produced. Within a certain space the positive and negative qualities of each planet are supreme, so they maintain their respective distances from each other, yet there is one grand center about which they all revolve. The chemical product, or the friction from motion, or both, generates what is known as electricity. First the centripetal effect is to overcharge the center, when a centrifugal reaction obtains and we have the duality complete in positive and negative magnetic currents. The lines in the figure show only the negative ones, that is, those from the sun, and only a few of them. The sun being as large in comparison with the planets as the center field is larger than the dots it is easy to see how these currents reach all the planets, all the time, except when occasionally one planet gets in the way of another enough to shut off the currents from a small portion for a short time, as is illustrated by eclipses. This electricity reaches us in the form of a luminous force and not only enables us to see objects not luminous themselves, but it also vitalizes the earth, making it habitable and productive.

Some writers have asserted that there is no such thing in nature as a convergent ray. I concede the point and assert,

further, that there is no such thing as a divergent ray. It requires two or more rays to exhibit convergence or divergence, and when we have a multitude, as we have from the sun, there are both convergence and divergence, as is shown in the figure. Of course when we look at a small object some distance away the rays we receive in the pupil of the eye are divergent from each other as they radiate from the same points; but as the pupil is only about one-eighth of an inch in diameter the rays enter it so nearly parallel that they are assumed to be exactly so in our calculations.

Refraction is the deviation in its course a ray of light suffers in passing obliquely from one transparent medium to another of different density.

The amount of refraction is governed by a duality, the angle of incidence and density of medium; it is measured according to natural laws.

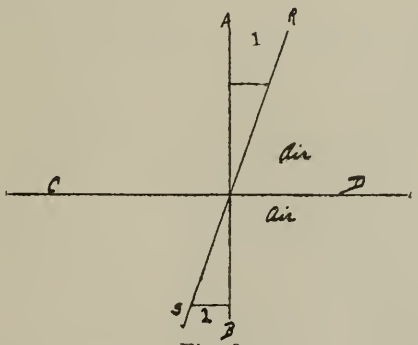


Fig. 2

Let the line R S, Fig. 2, represent a ray of light passing obliquely through air; it suffers no change in its course at the line C D, because there is no change in the density; therefore, the angles 1 and 2 formed by the ray with the line A B, are of equal size. Air being the medium through which all light comes before it can pass any other, and being the rarest

of all, it is taken as the standard or unit of density, that is, of resistance to the passage of light, and all other mediums are compared with it, the ratio they bear to it respectively is called their index of refraction.

The first thing required for the purpose of measurement of the amount of refraction is a line drawn perpendicular (at right angles) to the surface under consideration. If the sur-

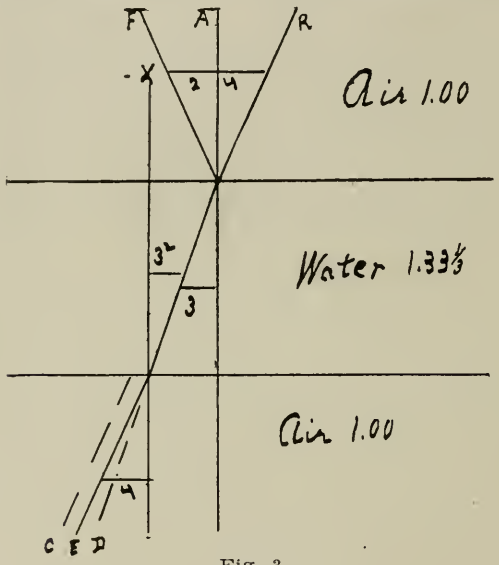


Fig. 3

face is horizontal, the perpendicular will be vertical; if the surface is oblique the perpendicular will be oblique also. An easy way to locate the perpendicular is to make the point where the ray strikes the second medium the center of a circle and put the perpendicular 90 degrees from the surface. Thus, if the surface is at an angle of 45 degrees the perpendicular will be at 135 degrees. Or if the surface is at 120 degrees the

perpendicular will be at 30 degrees. All degrees are numbered from the horizontal and begin at the right. All measurements are at right angles to the perpendiculars, and, as the denser the medium the slower the speed and the rarer the medium the greater the speed at which the ray travels, it follows that in measuring angles we must reverse the figures, therefore, if we bear in mind that we have only two sizes of angles and the small one is always in the denser of the two mediums it will be easy to master the very necessary preliminary work quickly.

Fig. 3 shows what would occur if a ray from R should come in contact with a body of water at the point where it crosses the line A. Its course would be changed, for the reason that its movement is swifter in the rare medium, and, its lower side, meeting the obstruction first, would be retarded in its progress, while the upper side would continue its speed, thus gaining on the other, so that the course of the ray through the denser medium would be toward D instead of in the direction of C. As it passes obliquely through the water, it will be seen the lower side would be released first, and, renewing its original pace, would gain on the other side, recovering what it had lost at the first surface, and would pass toward E, parallel to but not on the line of its original course.

From the amount of deviation as shown by the proportions of the angles formed in the two mediums, we learn the relative density, 4 is to 3 as 1.33 1/3 is to 1.00, therefore the index of refraction of water is 133 1/3. If we substitute glass for water we would have angles proportioned as 3 is to 2, hence the index of glass is 1.50. If we could substitute diamond the angles would be as 5 is to 2, hence the index of diamond is 2.50.

According to its index of refraction water would cause the ray to change its course so that the angle formed by the ray and the vertical line at 3 would be in proportion to that formed by the ray and vertical line at the same distance, 4, above the first surface, as 1 is to 1.33 1/3.

The same law applies in passing from the dense to

the rare medium below, the angle at 4 below being 133 1/3 times as great as that at 3.[2]

A ray is called incident before it enters the denser medium, refracted during its passage and emergent after it has passed.

The angle formed by the incident ray and the vertical line A, is called the angle of incidence; that formed by the re-

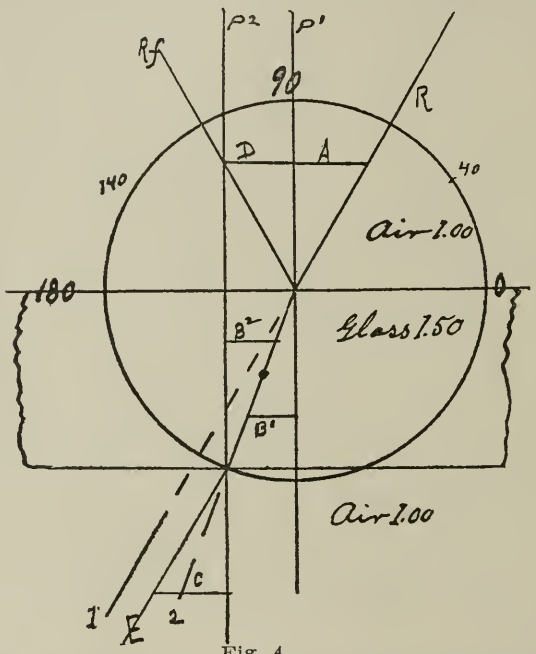


Fig. 4

fracted ray and the same line, the angle of refraction; and that formed by the emergent ray and the line x, the angle of emergence.

A ray, in making a passage as illustrated, suffers the loss of a portion by reflection at the first surface, and it is a law

of optics that the angle of reflection always equals the angle of incidence, hence it follows that the reflected portion would pass toward F forming another angle with the line A, called the angle of reflection.

It will be observed that the angles of emergence and incidence are of equal size; therefore, a ray starting at E, would pursue the same course, and R would be the emergent ray, which fact gives us another law, viz.: The course of returning rays is always upon the same lines on which they enter.

Fig. 4 illustrates the first essentials of refraction. Understand, the word means "to break." Rays passing obliquely from one transparent medium to another of different density suffer refraction. But they must not approach at too great an angle or they will suffer total reflection. Rays on the lines "P^1" and "P^2" would pass straight through the glass because they strike its surfaces perpendicularly. As the density of the air is only 1.00 while glass is 1.50 (it is really about 1.53, but we use the 1.50 because it is easier to make the calculations clear to the student and the principle is shown as well), it follows that the ray will pass through the air faster than through the glass, hence to get the comparative rate of speed in the two mediums we reverse the figures, giving air the 1.50 and glass the 1.00. Then one inquires what becomes of the quantity of light, indicated by the figures as approaching the glass, greater than its evident capacity to receive. It is reflected as perpendicularly as the ray strikes. But when a ray strikes obliquely, as the line R, the reflected portion takes a direction as oblique as the ray approached and on the other side of the perpendicular. The amount lost by reflection increases as the angle of approach increases until the "limit angle" is reached, which is about fifty degrees from the perpendicular, at the points marked 40 and 140, when total reflection occurs. The ray R, called the incident ray, forms an angle, A, with the perpendicular and it is called the angle of incidence. Imagine there is nothing shown but the two mediums, the line R, the perpendicular and the line A. As the index

figure of glass is three halves while that of air is only two, and as the speed of the ray in the air is the greater, we know the angle must be also, hence we take the measure where it is easiest, that is, where it measures three points; (a point may be a millimeter, an eighth of an inch, or any other unit one chooses for a calculation); then go the same distance below the surface of the glass, B^1, and measure two points, because that represents the relative speed in the glass and the relative size of the angle therein; then draw the line R from surface to surface of the glass past the end of the line B^1, this is the refracted ray and the angle B^1, is the angle of refraction. Now imagine the line P^2 has just been drawn perpendicular to the lower surface of the glass where the ray strikes; we know the small angle is in the glass so we measure B^2, two points, then go as far on the other side of the surface and measure three points at C, then continue the ray from where we left it at the lower surface, toward E. This is the emergent ray and the angle formed by it with the perpendicular is the angle of emergence. Note that a ray, whether refracted or reflected, always crosses the perpendicular; that the angle A is to B^1 as 3 is to 2, and the angle B^2 is to C as 2 is to 3. The greater angle is always in the rarer medium, therefore if we know the index figures of the two mediums we can find where a ray will go. The angle of reflection is always equal to the angle of incidence. The ray R starts toward 1, is broken at the first surface and takes direction of 2, is broken at the second surface and takes final course to E. The reason a ray suffers refraction is that as it approaches obliquely the lower side of it strikes the slow speed first and as it leaves the denser medium the lower side resumes the rapid speed first. This is why in entering a denser medium the ray is broken toward the perpendicular and in leaving is broken from the perpendicular. The dot in the middle of the refracted section is to show that if it were the luminous point from which rays started the one directed upward and that directed downward would strike the respective surfaces at the same angles, hence the angle of

incidence, A, and the angle of emergence, C, are of equal size. But this is not always true, except in plane surfaces.

The points of particular interest in connection with this illustration are:

First. An oblique ray, passing from one transparent medium to another of different density suffers a change in its path, but not in its general direction.

Second. The denser the medium the slower the rate of speed of the ray.

Third. The reflected portion passes away at the same angle the ray approached.

Fourth. The small angle is always in the denser medium.

Fifth. There is a duality of mediums, a duality of connecting surfaces, a duality of perpendiculars and a duality of indices.

Sixth. There is a positive refraction as the ray enters the denser medium and a negative refraction as it leaves; that is, the ray is broken toward the perpendicular on entering and from it on leaving.

Seventh. There is a double duality of sections of the ray, incident, reflected, refracted and emergent, and corresponding angles formed by the sections and the perpendiculars.

Eighth. A ray suffers reflection, refraction, dispersion and absorption. The two named last are not shown in the drawing.

Ninth. The density of the glass compared with air is as 1.50 is to 1.00, therefore, the angles in the air are always one-half larger than in the glass, and, being given one we can always find the other.

Tenth. The comparative angles are always on opposite sides of the perpendicular, as they are on opposite sides of the connecting surfaces of the mediums.

Eleventh. The amount lost by reflection gradually increases until the limit-angle is reached, when the ray is totally reflected.

Twelfth. The limit-angle, where total reflection occurs, symbolizes one's limit of endurance, of patience, of capacity, etc., metaphysically and physically.

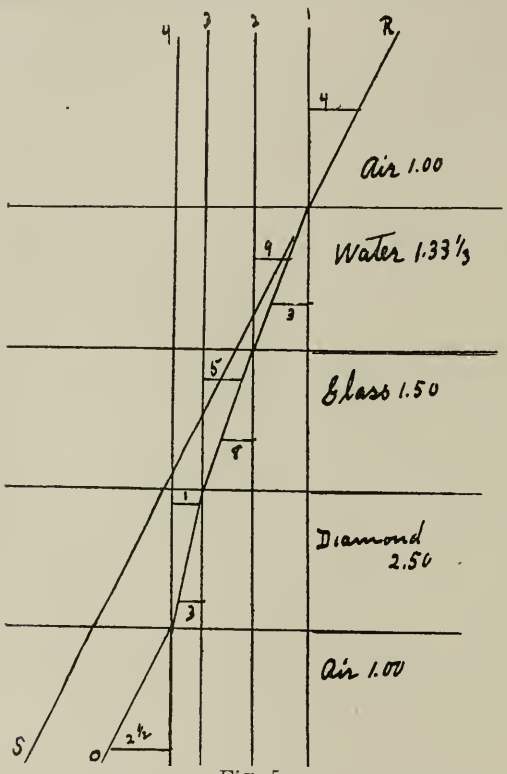


Fig. 5

In order to make indices clearer, Fig. 5 is given at the risk of confusing the student. Here the ray, R, starts toward S but is refracted by several mediums and finally passes away on the line O. The indices given are all in comparison with

air, so that in the refraction which occurs as the ray passes from water to glass and from glass to diamond, we must find the relation they bear to each other, which is easy because all we have to do is find the ratio the figures given bear to each other; thus 1.33 1/3=4/3 and 1.50=3/2; then multiplying the denominators to get the common denominator, we get 6; as 4/3=8/6 and 3/2=9/6, the relation between water and glass is as 8 to 9, and if 8 is 100 per cent, 9 is 1.12 1/2 per cent, hence the last figure is the index of glass when compared with water. The figures for glass being 1.50=3/2 and for diamond 2.50=5/2, there is already a common denominator, and they bear the relation of 3 to 5; if 3 is 100 per cent, 5 is 1.66 2/3 per cent, and is the index of diamond compared with glass. The lengths of lines in the cut bear out the respective indices in their proportion to each other. The line 4 is to 3 as 1.33 1/3 is to 1.00; the line 9 is to 8 as 1.50 is to 1.33 1/3; the line 5 is to 3 as 2.50 is to 1.50; the line 1 is to 2 1/2 as 1.00 is to 2.50. The vertical lines 1, 2, 3, 4 are the perpendiculars to the surfaces where refractions occur.

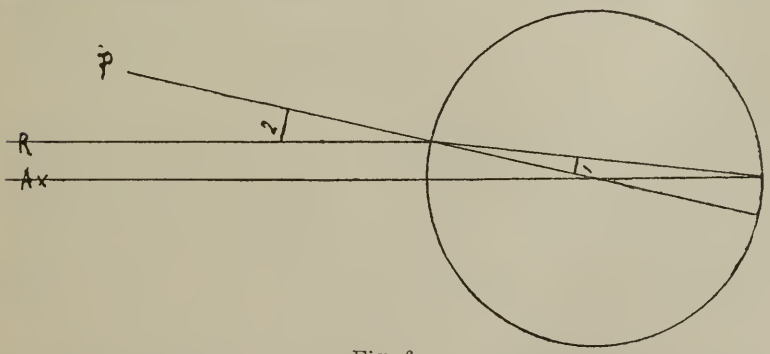


Fig. 6

Fig. 6 shows how to find the index of a medium if both the incident and refracted sections and the index of the rare medium are given. Knowing that the index of air is 1.00

all that need be done is to erect the perpendicular, P, measure the angle at 1 and go as far outside the globe, along the line P, as the first angle is inside, measure the angle at 2, which, being 2.22 times as great as 1, proves the index of such a medium would be 2.22.

A globe of glass, with 1.50 index focuses beyond itself, as is shown in Fig. 7.

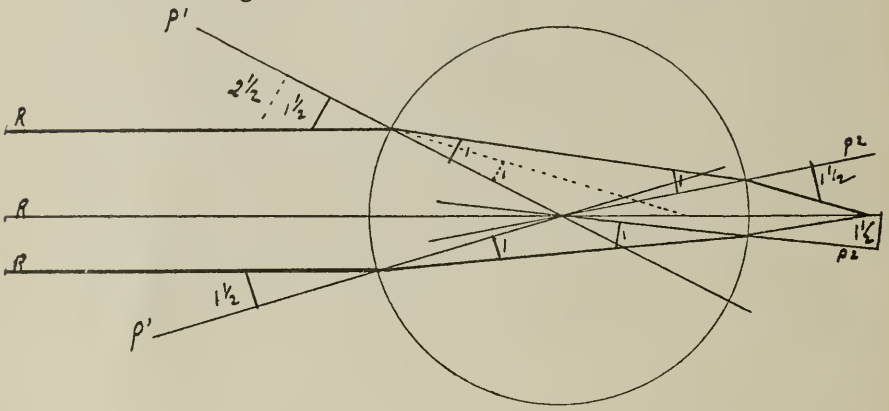


Fig. 7

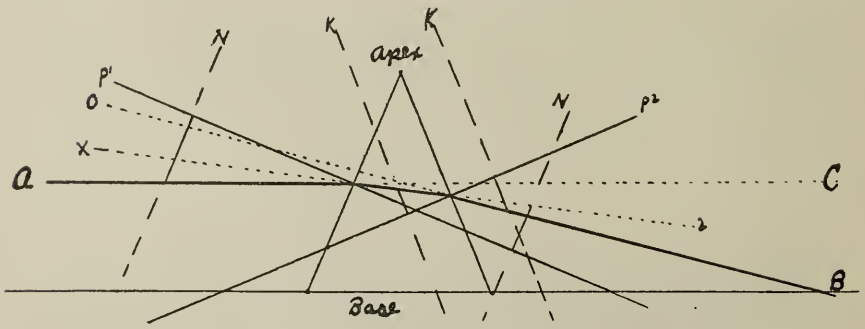


Fig. 8

If the globe were a diamond, the focus would be as shown by the dotted lines, Fig. 7, the angle of incidence 2 1/2 and angle of refraction 1. I do not like to make one drawing tell too many things, but it is not desired to give too much prominence to practically useless features, which, nevertheless, are valuable theoretically.

Fig. 8 shows what happens to a ray in passing a prism. In Figs. 4 and 5, the surfaces were parallel, so that had rays approached perpendicular to the first surface, they would have also been perpendicular to the second and would have passed through without refraction. By this figure it will be seen no ray can pass without refraction, for if it came to the first surface perpendicularly it would be refracted by the second surface, because it is not parallel with the first. A ray starting from A toward C would be refracted by the first surface toward 2, and by the second surface toward B; and a ray starting from B toward O would first be changed to the direction X, then toward A. Thus an eye at A would see at C an object really situated at B, and an eye at B would see at O an object really located at A. Rays are always refracted toward the base of a prism and objects seen through a prism always appear nearer the apex.

As there is no transparent material having the index indicated by Fig. 6 and as glass would only focus as shown by Fig. 7, if we wanted a glass apparatus that would focus at its posterior pole we would have to make the anterior curvature from the Center C, Fig. 9, instead of from the center, N, thus making up in angle of incidence what is lacking in density. The refraction of R^1 having been measured, and the surface being spherical, we know where R^2 would go without measuring.

These apparent objects are called virtual objects because we do not see the real thing. As a matter of strict fact all who wear glasses only see virtual objects, for convex lenses magnify and concave ones minify. This is compensated for, however, by the facts that those who need convex lenses have

eyes that do not magnify as much as normal ones and those who need concave lenses have eyes that magnify more than normal, thus nature takes care of her children. In figure 8 the lines P^1 and P^2 are perpendicular to the surfaces, and the lines N N and K K show where the angles were measured.

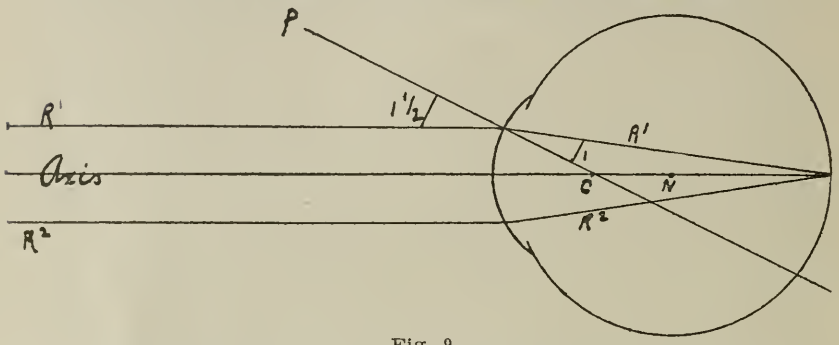


Fig. 9

Prisms in multitudinous quantities form all lenses of every description. If placed bases together as shown in Fig. 10, there will be positive effects, hence such lenses are known as +. If the prisms are reversed as shown in Fig. 11, the effects are negative, hence lenses having this general form are known as —.

Fig. 10

Observe in both Figs. 10 and 11 the central lines pass through without refraction; this is because the two surfaces are in such relative position that they are parallel at these lines and the rays, being perpendicular, pass without refraction; hence the lines are called axes and the rays are axial rays.

Note in Fig. 10 that while parallel rays meet on the axis

after passing the prisms, they do not meet at a point common to all. In order to utilize the principles of refraction for optical purposes it is necessary to grind curved surfaces so there will be the effects of a multitude of prisms of different angles in order that there may be at least approximately one

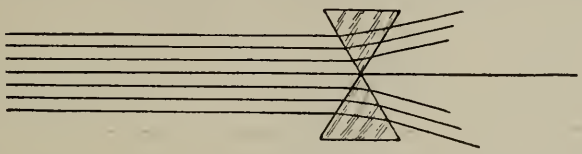


Fig. 11

focal point for all rays that come parallel with the axis or divergent from the same given points on the axis. If the rays approach parallel with the axis they meet at the nearest possible point on the axis after passing the lens; this is called the principal focus.

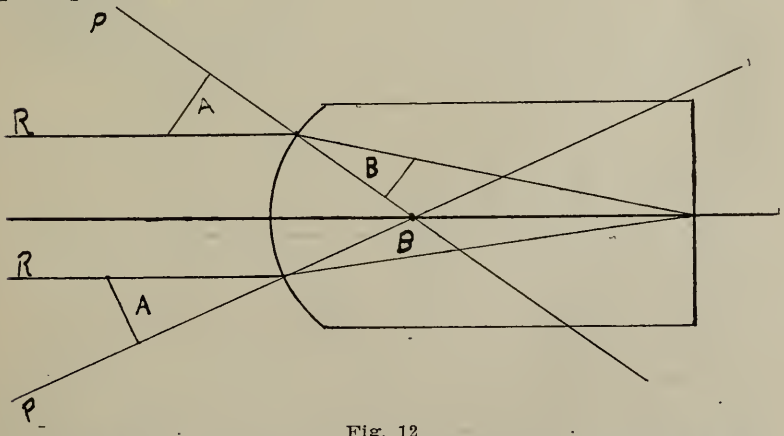


Fig. 12

In Fig. 12, R and R approach parallel to the axis but at different distances from it, but the angles A and B bear the

same relation to each other in both instances and the result is that the rays focus at the same point on the axis. The fact that the curvature would, if continued, form a perfect sphere, caused the name spherical to be given such lenses. They may be either convex or concave, and each class is subject to three forms of construction as shown in Fig. 13.

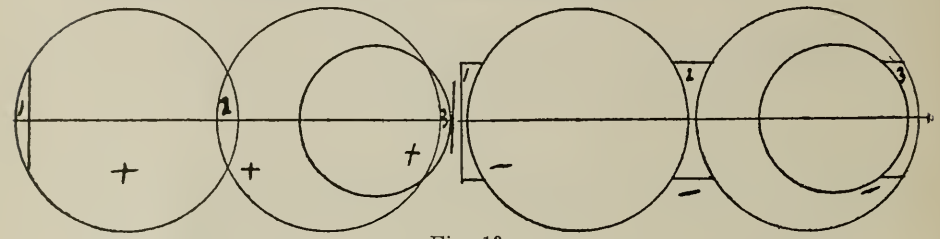


Fig. 13

Fig. 13 illustrates the positive (+) and negative (—) structure of spherical lenses, one set is cut from the globes and one set so that globes would fit in them. Particular attention is directed to understanding the little essentials, which, I have found in school work, are often neglected. Fig. 14 shows edge views of lenses corresponding to Fig. 13.

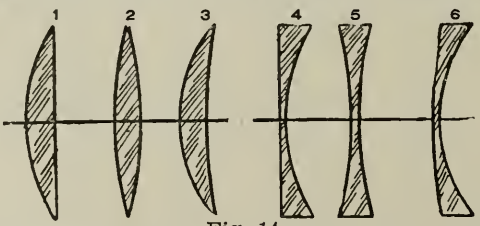


Fig. 14

These are the popular forms, but there are many others embodying the same principles, such as the lenticulars, as they are called, for which a piece of plane glass is used to get the size, and in the center a small space is ground to desired curvatures in — and for + a small piece is cemented on. Fig. 15

shows first the front, then the edge views of such lenses. Then there are lenses ground like Fig. 15 on + lenses 1, 2, 3, Fig. 14, for the purpose of making strong lenses without the thick edges of 4, 5 and 6, Fig. 14. Then there are alleged toric lenses and real torics and sphero-torics. The American standard periscopic or meniscus lenses are ground with fixed amount of concavity on one side and with enough convexity on the other to give the desired focal power. During the past few years opticians who are not content with reasonable prices for ordinary lenses, foisted upon gullible people, including many oculists, what they call a toric lens, but which is nothing more or less than a deep concavity on one side of a meniscus. They are not only of no benefit, but are really harm-

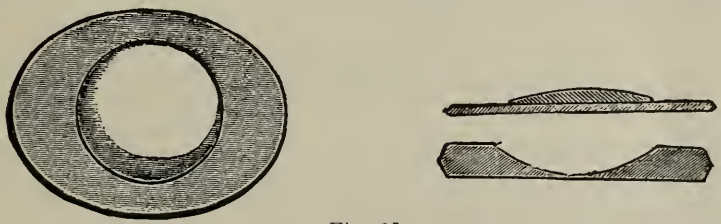


Fig. 15

ful, because they intensify spherical and chromatic aberration in the stronger numbers, and oculists who endorse them advertise their culpable ignorance of optical principles and physical laws generally. Before explaining the toric lens I must give some preliminary facts:

Chemically glass belongs to the class called salts. Common glass is made by melting together silica (sand), calcium carbonate (limestone), and sodium carbonate (soda). If potassium be substituted for sodium, and lead for calcium, the quality is finer; in other words, the finer the material used the better the product. Flint is clearer than crown glass because there is lead in its composition, but it is softer, which gives it a peculiar quality to be described.

It is well known that natural light is composed by a com-

bination of all the spectral colors. The passage of a ray through any medium which reduces its original speed causes a derangement of its components, the medium absorbs a portion, while it also makes an attempt to disperse it into its elementary colors; so, any ray, in passing from one transparent medium to another of different density, suffers from reflection, dispersion and absorption; and, if it passes obliquely, it also suffers refraction.

Were it not for reflection we could not see objects which are not luminous; and, were it not for dispersion and absorption the power of the reflected light would be so great as to be painful to the nerves of vision.

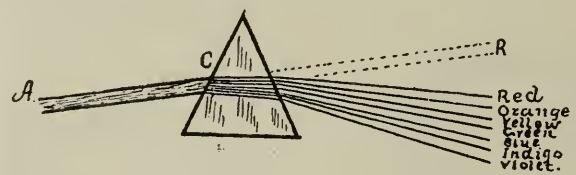


Fig. 16

Fig. 16 illustrates the dispersive power of glass, with the ray passing from A toward R, at such an angle of incidence that the greatest possible effect from the prism, C, is shown.

Flint glass, with a refractive power about equal to, has twice as much dispersive power as the crown glass from which spectacle lenses are made, so that a prism of half as great angle as the cut shows, would, if made from flint glass, exhibit as much dispersion. It was the discovery of this which enabled the makers of the finer grades of optical and mathematical instruments to attain their present approximate to perfection. Previously two factors interfered with the successful use of lenses with more than about twenty-five diameters magnifying power. These were chromatic and spherical aberration. No single lens will focus absolutely, because while the density is constant the angles at which the rays strike the surfaces increase steadily, as they are farther from

the axis, so that the effects illustrated by Fig. 16 are exhibited by the lens as shown in Fig. 17, the rays 1 and 1 show no aberration, while rays 2 and 2 illustrate, first, that the edge rays meet on the axis just a little sooner than the more central ones, thus, in high power lenses causing indistinct images to

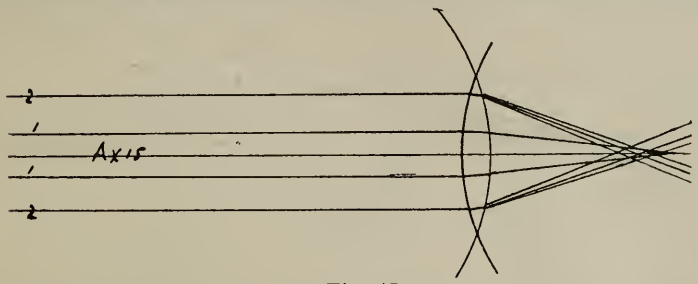


Fig. 17

be formed; second, the dispersion would also cause color disturbances. The discovery of the difference between crown and flint glass enabled the manufacturers to overcome both of these factors and thus utilize the whole field of the lens. Formerly it was necessary to rough-grind the marginal field to even partly overcome the difficulties.

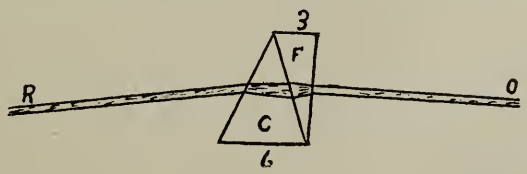


Fig. 18

Fig. 18 shows the dispersion of the ray from R in the crown glass, C, and the contrary effect in the flint glass, F, which reunites the parts, and the emergent ray becomes white again. The flint glass, 3, being half as strong in refractive power as the crown, 6, and of the same dispersive power, the

result is a refractive power of 3 in the combination, without any dispersion. It is upon this principle that achromatic and aplanatic lenses are made. The first means the chromatic aberration is corrected, and the second is a lens in which all faults are overcome.

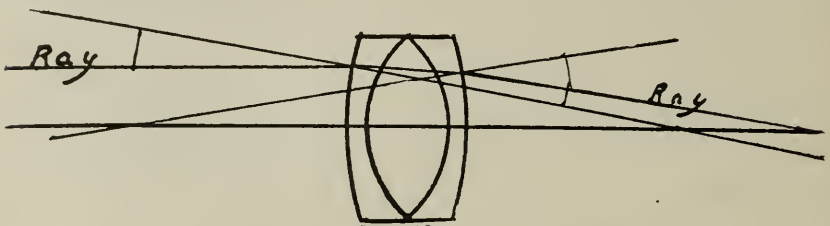


Fig. 19

Fig. 19 shows how an aplanatic lens is constructed; the center piece being of the formula C, while the two outer pieces are of the formula F, each having one-fourth of the refractive power of the inner piece. It would work just as well with reference to the dispersion if the two outer pieces were one, and half as strong as the center piece, but by making two pieces and putting one on either side another defect was overcome, namely, spherical aberration, caused by the edge rays focusing sooner than the ones which pass through the lens near the center. Remember there are two laws which govern the amount of refraction by lenses: that of density and that of angle at which rays strike the surfaces.

Now we may see, with the aid of Figs. 20 and 21, the objects of a toric lens. First, understand that in architecture a tore is an ornament placed on pillars; it would be well illustrated by putting a bicycle tire around a large pillar, showing its long curve around the pillar and its short curve around itself; hence a toric lens is so named because it has not a spherical curvature but is curved in all meridians. It also illustrates aptly a natural law that in non-spherical surfaces the two principal meridians are always at right angles to each

other, and when they are taken care of the other meridians are also provided for without further attention. Yet there are alleged scientific oculists and opticians who prescribe and make cross-cylinder lenses with axes not at right angles to each other, and when criticized declare, "Well, I get better results from them anyhow," thus clinching the proof they do not know their business.

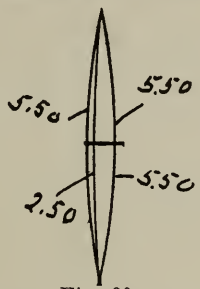


Fig. 20

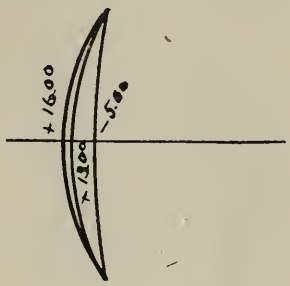


Fig. 21

Fig. 20 shows how a sphero-toric lens is made where the two principal meridians are + 11. and +8. respectively. Add the figures above the axis for the maximum meridian, and those below the axis for the minimum. When the student is familiar with prescription writing, as detailed later, this will be more comprehensive. Fig. 21 shows how a sphero-toric can be and often is made, which aborts the purpose for which nature gave the principle. By first grinding —5. on one side there was caused a necessity for + 16. curvature in the meridian of maximum need to get the + 11. required, and for + 13. in the meridian of minimum need to get the + 8. when the facts illustrated by Fig. 19 prove that the whole object in making lenses as flat as possible to get the desired effects is because the nearer flat they are the nearer perfect they are. Nature made the crystalline lens of the eye on the same principles as the aplanatic lens shown here, and, I believe, for the same reasons, hence I assert that the rod-and-

cone theory of color-blindness is wrong, that most cases of color-blindness are color ignorance and the remainder are due to homogenity of the lens structure.

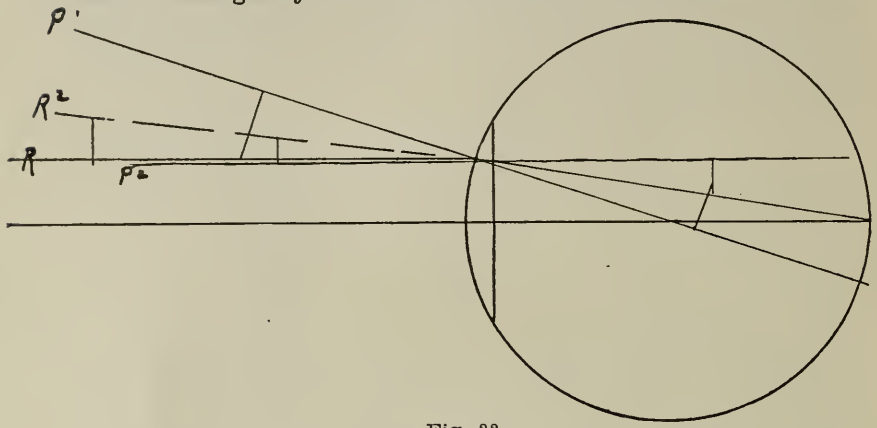


Fig. 22

Fig. 22 shows how a plano-convex lens focuses parallel rays practically at the opposite side of the circle of which the lens is a segment. This would be true of any size circle or globe of glass and from this fact the system of numbering lenses was evolved. The word "meter" means "measure," hence a circle one meter in diameter was chosen as the standard and all lenses are numbered inversely as their focal power in inches equals meters or parts of meters. The numbers apply to — lenses as they neutralize their equivalents in +, for the — are only positive by reflection, as shown in Fig. 26. Thus having a standard,

No. 1.00 curvature equals 1 meter focal power.
No. 2.00 curvature equals 1-2 meter focal power.
No. 3.00 curvature equals 1-3 meter focal power.
No. 4.00 curvature equals 1-4 meter focal power.
No. 5.00 curvature equals 1-5 meter focal power.
No. 6.00 curvature equals 1-6 meter focal power.

No. 7.00 curvature equals 1-7 meter focal power.
No. 8.00 curvature equals 1-8 meter focal power.
No. 9.00 curvature equals 1-9 meter focal power.
No. 10.00 curvature equals 1-10 meter focal power.

The metric system is a decimal system of weights and measures used almost universally. Its unit is 1 meter, the ten-millionth part of one-quarter of a meridian circle of the earth.

1,000 meters = 1 kilometer.
100 meters = 1 hectometer.
10 meters = 1 decameter.
1 meter = 1 meter.
.1 meter = 1 decimeter.
.01 meter = 1 centimeter.
.001 meter = 1 millimeter.

As many are not familiar with the metric system, except as we use it in money, and few know it is subdivided metrically, I would explain that a meter is 39.368 inches, or, for mental calculations, call it 40 inches. Then

No. 1.00 curvature equals 40 inches focus.
No. 2.00 curvature equals 20 inches focus.
No. 3.00 curvature equals 13 inches focus.
No. 4.00 curvature equals 10 inches focus.
No. 5.00 curvature equals 8 inches focus.

and so on. Having the number, to find the focus, divide it into 40; or, having the focus, to find the number, divide it into 40. Thus, 15 inches focus divided into 40 goes 2 2/3 times. Express it decimally as 2.66, leaving out the small fraction. Then remember the standard is not quite 40 inches, but is exactly 1.00 and that 1.00 cut into eighths would be .12½ .25, .37½, .50, .62½, .75, .87½, 1.00. We arbitrarily call the 2.66 a 2.62 because lenses are ground only to eighths. A No. .50 would go into 40 just 80 times, hence the focus of a + .50 lens would be twice as far as + 1.00 and that of a + 2.00 would be half as far as plus 1.00, or 20 inches. Thus having any figure in one column, to find its equivalent in

the other, divide it into 40. Or, to be more exact, divide it into 39,368.

The rule of calculation of indices, curvatures and focuses is: Having the focus desired and the index of refraction, to find the radius of curvature necessary, multiply the focus by the index less 1.00. Thus the focus of a No. 1.00 lens is 39.368 inches; the index of refraction of glass is 1.53. The .53 being in excess of the standard, air, is what we use. 39.368 × .53 equals 20.86504 inches or the radius of curvature upon which the lens must be ground. Thus we find the focus is a little shorter than the diameter of the circle, Fig. 22. Or, being given the radius and index, to find the focus, divide the radius by the index less 1.00. Or, being given the focus and radius, to find the index, divide the radius by the focus and add 1.00. If a biconvex is wanted the two radii must be twice as great as for a plano-convex; or if a meniscus is wanted the radius must be shortened; thus if + 10 is to be made meniscus form, with — 1.25 on one side, the radius of the + curvature would have to be shortened to make + 11.25 effect, so the — 1.25 would be neutralized and leave the full + .10.

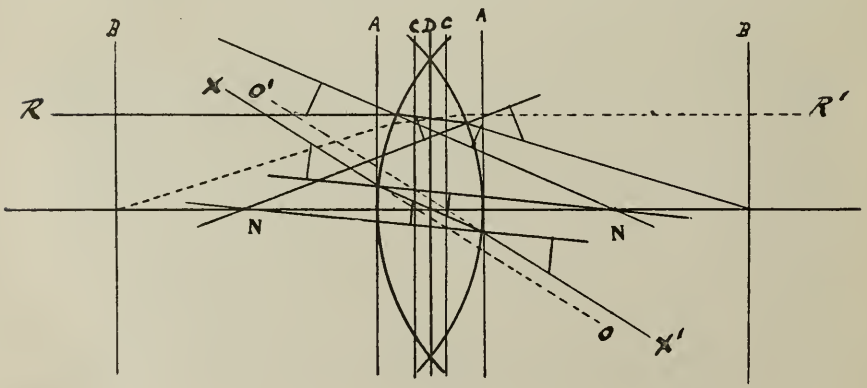


Fig. 23

Fig. 23 shows the principal points and planes of a bi-convex lens. The points are all on the axis and the planes are the vertical lines crossing the axis at the points. A and A locate the principal points and planes: B and B, the principal focal points and planes; C and C, the optical nodal points and planes; D, the optical center and its plane. N and N are the true nodal points, or centers of curvature of the respective surfaces, from which the perpendiculars are drawn. The lines R and R^1 show how rays approaching parallel to the axis will be focused at the principal focal points. The line X to

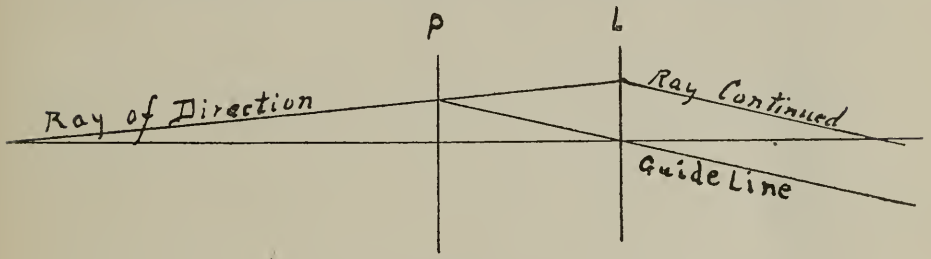


Fig. 24

X^1 shows how the secondary axial rays suffer refraction, and locate not only the optical nodal points, but the optical center; X passing in the direction O is refracted, crosses the principal axis at the optical center and passes away to X^1 as if it came from O^1. The optical nodal points are where the rays X and X^1 would cross the axis if they did not suffer refraction. This is of no great importance, but is of passing interest.

Conjugate foci are those points on either side of a + lens at which are situated an object and its image. If an object be placed at the point on the left, Fig. 24, and the ray of direction drawn to the lens L through the principal focal plane P, then a guide line be drawn from the point where the ray crosses the focal plane through the optical center of the lens,

then the ray continued parallel to the guide line, the point where it meets the axis will be the location of the image. It makes no difference where the ray of direction is made so it hits the lens. The reason this works exactly is that any ray starting divergent from the axis at the point where the line P crosses, will be refracted and pass away parallel to the axis, and any ray starting from any point on that plane, divergent from its secondary axis, represented by the guide-line, will be refracted and pass away parallel to that axis.

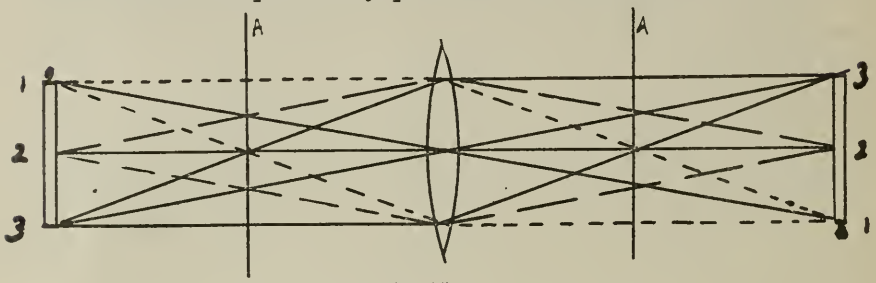


Fig. 25

Fig. 25 shows how the law of conjugate foci works in producing the image. The direct rays from 1 to 1 and from 3 to 3 are secondary axes and the divergent rays from each converge to the corresponding figures on the other side for the same reason that those from the principal axis 2 converge to it again at 2 on the other side. The fact that the secondary rays cross the principal axis at the optical center accounts for the reversal of the image. There is a multitude of secondary axes, but the extreme ones given show how they all act. If an object be placed at twice the principal focal distance from any lens the image will be formed at the same distance on the other side; if the object be at three times the focal distance the image will be nearer and half size; if object is at four, five, six, etc., times the principal focal distance, the picture will be nearer and proportionately smaller until the object is at infinity, when the image will be at the principal focal

point on the other side. Infinity is the distance sufficient so that any greater one makes no perceptible change in the location of the image; fifteen or twenty feet fairly express it. If the object be placed nearer than twice the focal distance the image will be farther away and enlarged. If the object be placed nearer the lens than the principal focus, the rays will be divergent after passing it and there will be no image. The point upon the principal axis where the object is placed is the first conjugate focal point, and the corresponding point on the other side of the lens, where the image is formed, is the second conjugate focal point, and the distances between each of those points and the lens are, respectively, the first and second conjugate focal distances. A rule to locate where images will be formed is to multiply the first conjugate focal distance by the focal length of the lens and divide the product by the difference between the first two figures; the result will be the second conjugate focal distance, which, in + lenses is always on the opposite side of the lens. The word "conjugate" means "yoked together," and it is applied to the points described because they are movable, the position of the second being always dependent upon the first. A better rule is to express the first conjugate focal distance in diopers, deduct it from the power of the lens and convert the remainder into inches. Having both conjugate foci to find the power of the lens, express both in diopters and add them.

Fig. 26 shows how a — lens forms images by reflection. Rays 1 and 3 are reflected as 2 and 4, while the principal axial ray is reflected back on its own line; 5 is reflected as 6, and others, not shown in the cut, fall in between, forming the image reversed. Other writers have misled readers by showing with Fig. 25 that + lenses form "real images reversed," and by Fig 27 that — lenses form "virtual images erect," which is not true, as the student may determine readily if he will take two lenses, one + and one —, look through each at some object, preferably a light at some distance, when he will see a "virtual" erect object with either, enlarged with the

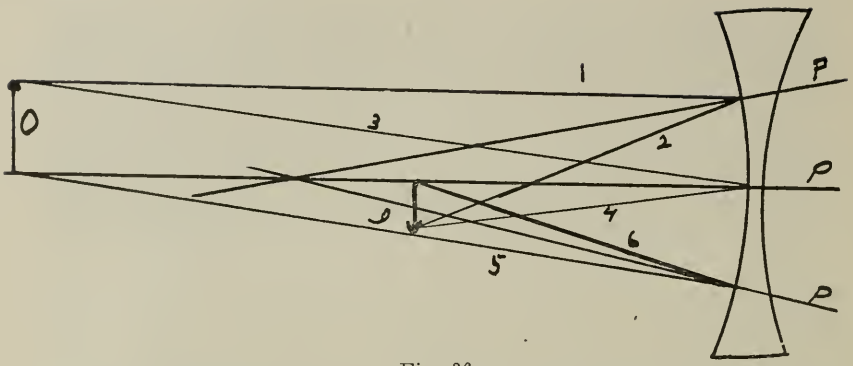


Fig. 26

+ and reduced with the —. Then by holding a piece of blank paper with the + lens between it and the light he will find a "real" image inverted; next hold the paper between the light and the — lens but a trifle lower and tilt the lens so it will reflect on the paper and he will see another "real" image, inverted, too.

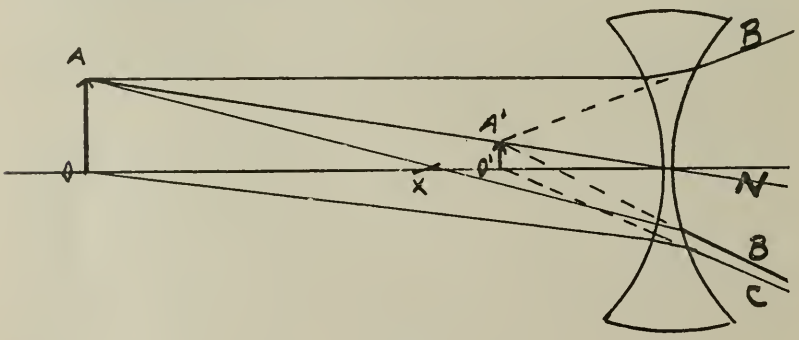


Fig. 27

If the effect of the combinations of spheres, placed some distance apart, is wanted, make a drawing like Fig. 28. L^1 and L^2 represent the lenses; P^1 and P^2 represent the respective

focal planes. In this cut the lenses are each + 3.25 and 1/16 inch represents an inch, thus the lenses are 6 inches apart. The incident ray A approaches L^1 divergent and crosses its plane P^1, in its course. For the reasons shown in Fig. 24, the ray would be refracted by L^1 and pass toward L^2 parallel to the guide line X drawn from the principal focal plane through the center of L^1; then projecting it backward on its new course until it strikes the plane P^2, drawing a guide line, X^2, from there through the center of the second lens, and con-

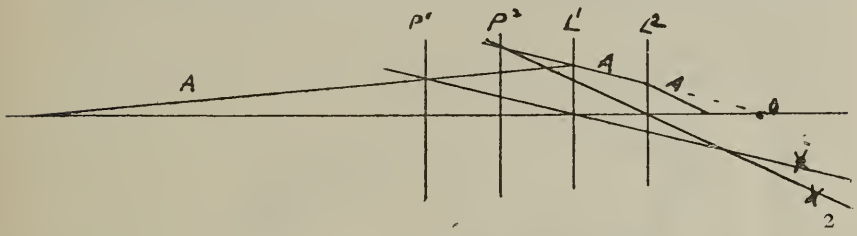


Fig. 28

tinuing the ray parallel to it until it strikes the axis, there will be the conjugate focus with the point from which the incident ray, A, started.

If the ray A approached parallel with the axis and the power of the lenses is known its course from the first to the second lens may be drawn arbitrarily, then proceed as above.

Fig. 29 shows another class of lenses, in which the prisms are arranged on either side of a line, instead of around a point; bases are at the line for + and apices at the line for —. These are called cylindrical lenses, because, if the curvatures of the + were continued they would form cylinders. Rays passing through on the lines marked "axis" suffer no refraction, but all others do. A + cylinder refracts all rays on either side of its axis toward the line, thus what is termed the "focus" of a cylinder is merely causing a lot of rays to form a wedge, the thin part being on the axis and the wide part being equal to the extreme width of the lens. A — cylinder refracts rays from its axis, hence can only form a

wedge of light by reflection. Cylinders are numbered same as spheres because in the meridian of greatest power of each they are equal to spheres of the same curvature. They are made only in the forms plano-convex and plano-concave because of the frequent necessity of combining them with sphericals to make what are called sphero-cylinders, or compound lenses. In toric lenses the sphere and cylinder are ground on the same side of the lenses. The points to be noted particularly with reference to cylinders are that there are two principal meridians, at right angles to each other; one is the axis, the other the meridian of maximum power; therefore in combining them with spheres, they impart that quality to the combination, the sphere furnishing all the power on the axis and both supplying power on the opposite meridian,

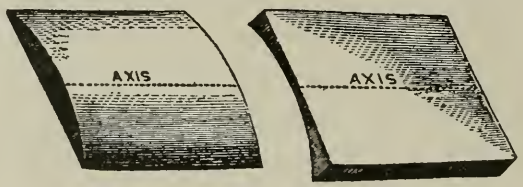


Fig. 29

where, if both have the same sign they must be added, and if of opposite signs they must be subtracted; if of opposite signs and of the same power they neutralize each other and the combination can be duplicated with a simple cylinder. See next chapter for this work.

Hold a prism, base down, a few inches from the eye, and look through it at some fixed object; there will be an apparent displacement of the object toward the apex of the prism, because the rays are broken toward the base. Move the prism from right to left and reverse, when there will be no movement of the object. Rotate the prism and the object will move in a circle with apex of prism.

Hold a + sphere in the same manner and there will be no displacement, because there are a great many prisms

arranged around a center. The object may appear enlarged more or less, governed by the distances. Move lens to and fro and the object will be displaced in the opposite direction. Rotate the lens and the object will remain stationary.

A — sphere treated in like manner causes the object to move with it, otherwise it will be just like the +, except that objects seen through it will appear reduced.

A + cylinder, held axis 90 and moved up and down will not displace the object; but when moved to and fro will displace the object in the opposite direction. Rotate it and the vertical meridian will go against the movement, while the horizontal meridian will go with it. This is because the apices of the cylinders are down on one side and up on the other.

A — cylinder axis 90, will cause no motion of object when moved up and down, but moved sidewise will cause a movement with the lens. Rotated it will cause the vertical meridian of the object to move with its motion while the horizontal will reverse, for the same reasons given for the + cylinders.

The prisms being reversed the effects are also, as a matter of course.

Knowing the peculiarities of each lens in its simplest form it is easy to find how many departments there are to a lens. For example, if a lens be shaken and objects move in every direction it is proof there is a sphere; if, in addition there is greater movement in one principal meridian than in the other it tells there is a cylinder, or if rotating distorts objects it tells of a cylinder; while if rotating moves the object in a circle, but does not distort it, a prism is present. If all the effects are there, all the causes are also.

This exhibition of law affords us a lesson in practice. We must know what symptoms, objective or subjective, mean, then if we find several symptoms we know there are several causes. Our symptoms are not like those of the old schools, a sort of guide to diagnosis only, but to complete analysis.

OCCIPITO FRONTALIS
ORBICULARIS PALPEBRARUM
TEMPORAL
ORBICULARIS ORIS
MASSETER
STERNO CLEIDO MASTOID
BICEPS
TRICEPS
PECTORALIS MAJOR
PECTORALIS MINOR
RECTUS ABDOMINALIS
OBLIQUUS EXTERNUS
SERRATUS MAGNUS
RECTUS FEMORIS
SARTORIUS
ADDUCTOR MUSCLES
BICEPS FEMORIS
GASTROCNEMIUS
SOLEUS
TENDO ACHILLIS

PRESCRIPTION WRITING.

Analysis and Neutralization of Lenses Prove a Simple Natural Law.

A + lens which brings parallel rays to a focus at one meter (39.368 inches) beyond it is taken as the standard of measure and is numbered 1.00. When the power is increased the focus is shortened; thus + 2.00 will focus at 1/2 the distance + 1.00 does; + 3.00 at 1/3; + 4.00 at 1/4, etc. For mental calculations, remember + 1.00 equals 40 inches focus.

As + 1.00 is the number, and 40 inches the focal length, of the unit of measurement, if we have the number of a lens and want to know its focal length we divide the number into 40, and the result is the figure desired. If we have the focal length and want the number, we divide 40 by the focal length and the result is the number. + 2.50 is of 16 inches focal length, because 2.50 is contained in 40 sixteen times. A lens of 10 inches focus would be + 4.00 because 10 is contained in 40 four times.

Lenses are not made in smaller fractions than eighths, so that when a figure is divided into 40 and the result is not in eighths we put it in the class to which it is nearest. For example, a 15-inch focus would give number 2.66 2/3 when the calculation is made thus: 40 divided by 15 equals 2.66 2/3. As 2.625 is the nearest, we so class it. It is customary to ignore the third figure in the decimal expression, so the number would be 2.62 or 2.63.

In practice it is rarely ever necessary to use smaller fractions than quarters, because, if the eye is below normal, so that + lenses are required, it should be given full correction, or a little more; and if it is above normal, so that — lenses are used, it should be undercorrected. That is, if + 1.12 is called for by the test, give + 1.25; if — 1.12 is the test, give — 1.00

The word "dioptre" means "to see through," hence it was chosen as the name for the unit of measure of lenses.

As has been shown in the chapter on refraction, — lenses are negative quantities, made by reversing the order in which prisms are used for +, therefore, the numbering applies to both. Also to cylinders.

It is easy to tell + from —, because if a + lens is held between the eye and an object and moved back and forth to right and left, or up and down, or moved back and forth between the eye and the object, the object will appear to move in the direction opposite to that in which the lens is moved, and the stronger the lens the more decided the motion. Take — lenses and the motion is with the movement of the lens.

Spherical lenses have equal power in all meridians, while cylindricals have power only when moved across the line corresponding to the axis. To find the axis of a cylinder, hold it between the eye and some straight object and rotate it. The object will appear distorted in shape except when either the axis or the meridian at right angles to the axis is on the

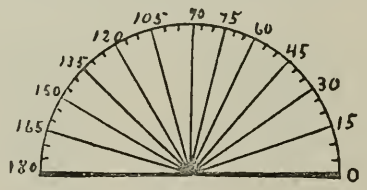


Fig. 30

line corresponding to the correct position of the object. Having found that position, move the lens sidewise and up and down; the meridian where there is no motion to the object is the axis. Make a mark on the edge of the lens showing where the axis is, then lay the lens flat on Fig. 30, center over center, and read the meridian from the figures. The inside of the lens must be down if the axis is oblique, otherwise an axis which is really 60 will register 120, or as far on the other

side of 90; axis 45 would register 135; axis 15 would register 165, etc., or lay the lens on Fig. 30 outside down and have an extra set of figures, reversed, that is, begin numbering at the left and number toward the right. If it registers 90 or 180 it is as registered with either set of figures.

Sphero-cylinders will cause the object to move in all directions, but in one meridian there will be the greatest, and in the one at right angles to it, the least motion. Locate the two principal meridians as described in the case of cylinders.

A sphero-cylinder-prism or sphero-prism lens will cause, not only the movement described for sphero-cylinders, spheres or cylinders, but the prism will displace the object towards its apex. The prism, base reversed, which replaces the object, is the measure of the prism in the lens. If the prism in the lens is base in it will require the same degree of prism, base out, to neutralize it.

A prism alone will not distort or move objects seen through them, except as the prism is rotated it will hold the virtual object in perfect shape, constantly in line with the apex.

To ascertain the number of a lens use lenses of the opposite kind which have the numbers on them, to neutralize the one unknown. If a + lens of unknown power be neutralized with a — 1.00 sphere we know it must be a + 1.00. If a + 1.00 cylinder axis 90 stops all motion in a — cylinder we know it must be — 1.00 axis 90. If we have a + compound (sphero-cylinder) and — 1.00 — 1.50 axis 45 neutralizes it, we know it is + 1.00 + 1.50 axis 45. If it is a compound and + 1.00 — 2.50 axis 180 neutralizes it we know it is — 1.00 + 2.50 axis 180. If — 1.50 + 2.50 axis 90 neutralized, it would mean the same. There are such things as crossed-cylinders, but people who understand their business never have any use for them, except in the very rare instances where the astigmatic error is so great that a sphero-cylinder would give more spherical and chromatic aberration. Even then, the sphero-toric lens (one in which there is a spherical curvature on one surface, and both

a spherical and cylindrical curvature on the other) is better in most cases. It is a fact, however, that all compound lenses are cross-cylinders in effect.

One of the most important features of optical work is the writing of prescriptions correctly, yet more errors are committed in this respect than in any other, except, possibly, the prescribing of — lenses where + should be used.

The incorrect writing does not affect the result so far as the patient is concerned, but it frequently involves more work for the optician who grinds the lenses. For example: a combination written + 2.00 — 2.50 axis 180 means a + spherical lens is combined with a — cylindrical with its axis at 180, or the horizontal meridian.

In analyzing this we must remember that the 180 is not a lens, but is the particular meridian upon which the axis of the cylinder is placed, and signifies that the cylinder has no power there. Next, we must remember that spherical lenses have power in all meridians equally, so the power of the combination on the horizontal meridian is furnished entirely by

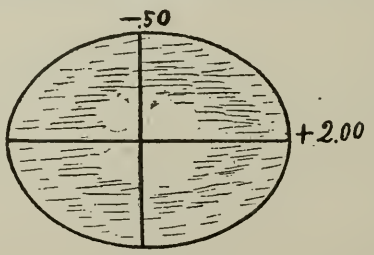


Fig. 31

the spherical, and is, of course, + 2.00. Next, the other principal meridian is always at right angles to the first, which makes it the 90th meridian; on this line both lenses have power, and as one is + while the other is —, the real effect is only the difference between them. The — being 2.50 while the + is only 2.00, the balance is in favor of the — by .50, so,

when the combination is made into a lens the power in its two principal meridians will be represented by Fig. 31.

Had the prescription been written — .50 + 2.50 axis 90, the effect would be the same, because now the axis of the cylinder is vertical, and it has no power on its axis, while the — sphere, having power in all meridians, takes full effect on the vertical, and on the opposite meridian the + 2.50 neutralizes the — .50 and has + 2.00 remainder.

An easy way to learn the difference between the effects of spheres and cylinders is to make a drawing like Fig. 31, which shows only the 90th and 180th meridians, and draw oblique lines through the center to designate other meridians, say the 30th, 60th, 120th and 150th, then on the one where the axis of the cylinder is placed put "0" and on the one at right angles to it put the power of the cylinder, then on the lines at either side of the axis put one-third of the power and on those at either side of the meridian where the full power is recorded put two-thirds of the power, then make another figure just like it, except on every meridian put the power of the sphere; thus both sides of the lens will be represented. To get the full power of the lens add the figures representing the same meridians if the signs are alike and subtract if the signs differ. In practice if we take care of the two principal meridians natural law takes care of the rest.

Manufacturing opticians carry what they call blank cylinders in stock: that is, a square piece of glass with the cylinder ground on one surface, and grind whatever sphere is desired on the other side, then lay a pattern on and cut the lens so the axis of the cylinder is at the proper meridian. In the prescription as written first it would require the grinding of + 2.00 while as written last it would only require — .50, a saving of three-fourths of the work. If all practitioners would observe these points it would facilitate greater speed in filling their prescriptions and often result in lighter weight lenses.

The following examples will be helpful in analyzing and proving correct and incorrect prescription writing:

+ 1.00	+ 1.00	ax.	90		
+ .50	+ 1.50	ax.	45		
+ 1.00	+ .75	ax.	60		or any other axis, would
— 1.00	— 2.00	ax.	120		be correct, because the
— 2.00	— 1.50	ax.	75	}	signs are alike; or, dif-
— 1.00	— 1.00	ax.	150		fering, the cylinder is at
+ 1.00	— 2.00	ax.	135		least twice as strong as
— 1.00	+ 2.00	ax.	165		the sphere.
+ 1.00	— 3.00	ax.	180		
— 1.50	+ 4.00	ax.	140		

+ 1.00	— .50	ax.	60		or any other axes, are
+ 1.50	— 2.00	ax.	180		wrong, because the signs
— 1.00	+ .75	ax.	90	}	differ, and the cylinders
— 1.00	+ 1.50	ax.	45		are less than twice as
					strong as the spheres.

The meridian given as the location of the axis of the cylinder is called the first principal meridian and the one opposite to it is the second principal meridian.

As lenses are to supply deficiencies and neutralize overdevelopments of the dioptric systems of the eyes, it is in order to explain some of the physical qualities of those organs here.

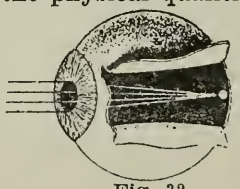


Fig. 32

Normal and defective eyes are named, respectively, emmetropic and ametropic. The latter are divided into two classes, the deficient ones are hypermetropic, or hyperopic, while the overdeveloped ones are myopic. The first are sometimes called far-sighted and the latter near-sighted.

Fig. 32 shows how the retina of the emmetropic eye is situated at the principal focus of the dioptric system. This eye requires no lens because its focus is correct without it.

Fig. 33 shows the retina of a hyperopic eye in front of the principal focus, because the eye is too short on its axis, or be-

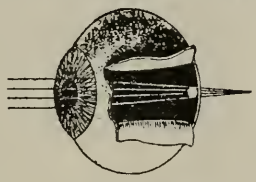


Fig. 33

cause the cornea or lens, or both, are of deficient curvature. This eye needs a + lens to shorten the focus by increasing the power of the apparatus.

Fig. 34 shows the retina of a myopic eye behind the principal focus, because the eye is too long on its axis, or because

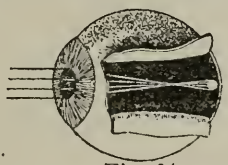


Fig. 34

the cornea or lens, or both, are of too great curvature. This eye needs a — lens to lengthen the focus by neutralizing the excess power of the dioptric system.

In many cases the cornea is not of spherical curvature, but is not irregular, and it is one of Nature's laws that all non-spherical, regular curvatures have two principal meridians, at right angles to each other. In architecture such a surface is called toric. It is well illustrated by a bicycle tire which has a long curve around the wheel and a short one around the tire. Imagine a piece of glass like that and it is easy to see the shortest curve would focus sooner than the long one, hence if light was permitted to pass through the whole surface of a lens at once there would be no focus.

Let Fig. 35 represent the curves of the two principal me-

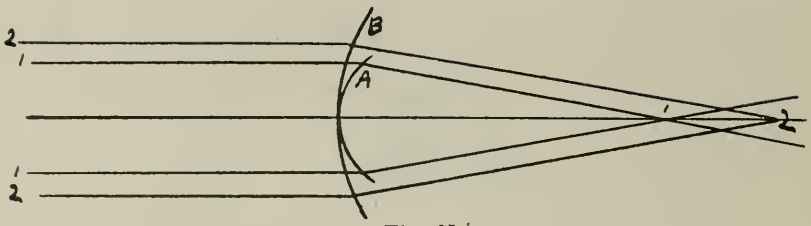


Fig. 35

ridians of a lens, A being the vertical and B the horizontal. The rays 1 and 1 would focus at 1 and the rays 2 and 2 would focus at 2. This lack of common focus is called astigmatism, meaning without a point. When an eye presents such a surface to rays, vision is, of course, more or less impaired, owing to the amount of the difference between the two principal

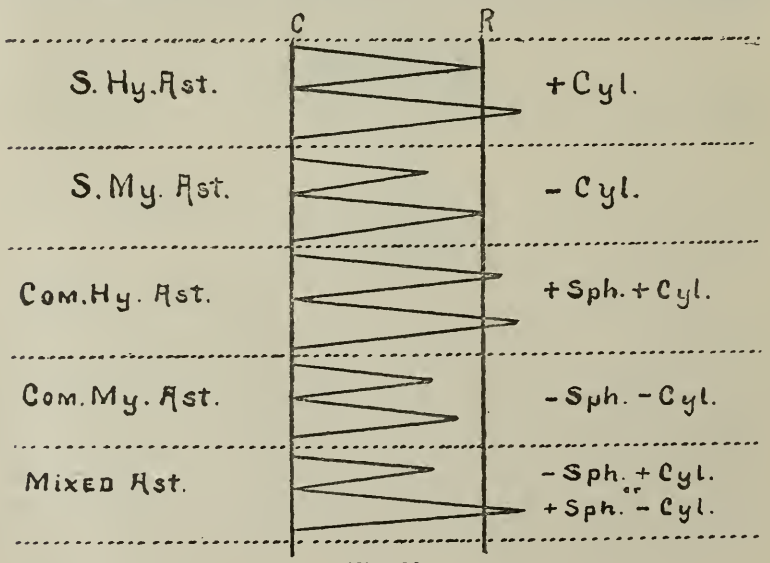


Fig. 36

meridians; sometimes there is so little difference it is not worth correcting, as will be shown in the chapter on measuring errors of refraction.

There are five different forms of regular astigmatism: Simple and compound hyperopic, simple and compound myopic and mixed. Fig 36 shows the principal focal points of the two principal meridians in each case; the myopic meridians focus too soon, the normal ones at the line R, and the hyperopic ones beyond the line; the first ones require — lenses, the second, none, and the third, + lenses; the amount of astigmatism is the distance between the two points. In mixed astigmatism one meridian is myopic and the other hyperopic.

Having seen that a cylindrical lens has no power on its axis, we have a law by which we analyze compound prescriptions, and it is essential to practice that it be understood perfectly, because by our method of fitting with or without cycloplegics we must nearly always transpose the prescription, as it comes from the trial frame, to put it in its simplest form. Sometimes it comes from the frame a compound and we transpose it into a simple cylinder. The two principal meridians, when drawn on paper form a cross, hence, in proceeding by the law we do one step at a time.

1st step: Draw a line representing the meridian designated as the axis of the cylinder.

2nd step: Write at one end of that line the sign and power of the sphere, because it is the only part of the combination that has power (viz., curvature), there.

3d step: Draw a line representing the other meridian which is always at right angles to the first and is 90 degrees from it on the circle; if the first is below 90, add 90 to find the degree; if the first is above 90, subtract 90. Thus if the first is 40 the second will be 130; if the first is 120, the second will be 30, etc.

4th step: Write at one end of the second line the effect of the two lenses; if both are + or both are —, add the figures and give the sign; if one is + and the other —, subtract the

less from the greater and use the remainder, giving the sign of the greater; if the signs differ but the power is equal of course there is nothing to be recorded and we put it "0."

5th step: Make a diagram of the focal points of the two meridians as shown in Fig. 36.

6th step: Begin writing the new prescription by writing, for the spherical part, + or —, whatever is needed for the meridian nearest normal.

7th step: Change the focal point to the line R, as the lens would do it, and change the focal point of the other meridian the same amount in the same direction.

8th step: Write for the cylindrical part, + or — cylinder of sufficient power to put the other meridian on the line R also and write for the axis the number of the meridian corrected by the sphere.

This law always works. If a prescription is written correctly it will prove it, and if wrong it will correct it. To prove the correctness of a transposition put the new prescription on a cross by steps 1, 2, 3, 4, then if it corresponds with the cross made from the original prescription and the cylinder is still of the same power, it is proved.

A short way to transpose a prescription that needs it is to take the difference between the powers of sphere and cylinder for the new sphere, then use the power of the old cylinder, but change the sign and reverse the axis.

No prescriptions need transposing unless the signs differ and the cylinder is less than twice as strong as the sphere.

It is always a case of mixed astigmatism when the signs differ and the cylinder is the least bit stronger than the sphere.

It is always a case of simple astigmatism when the signs differ and the cylinder is of the same power as the sphere.

It is always a case of compound astigmatism when the signs differ and the cylinder is weaker than the sphere.

The following examples will show the process of working out transpositions: Some people, who want to be mysterious, write a prescription like this:

+D. S. 1.00 ⌒ +D. C. 2.00 ax. 90.

D. for diopter, S. for sphere, ⌒ for combined with, D. for diopter, C. for cylinder. We know that the first lens, having no axis written, must be a sphere, and the other having an axis, is a cylinder. Being written together, a compound is intended, thus, + 1.00 + 2.00 ax. 90.

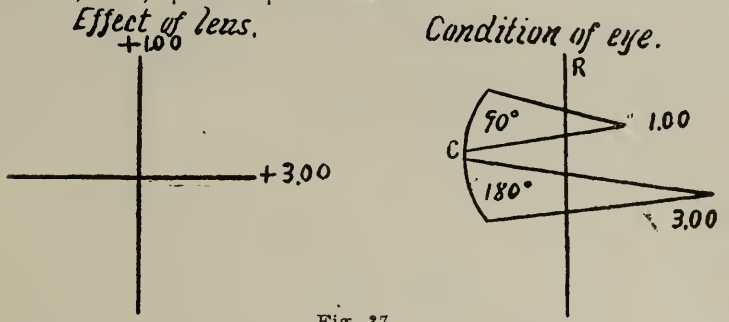


Fig. 37

Following the law, step by step, the prescription comes out as it went in, hence must be correct, and by Fig. 37 we see it is compound hyperopic astigmatism.

Another, L. + 3.50 — 3.50 ax. 180
R. + 4.00 — 5.00 ax. 30.

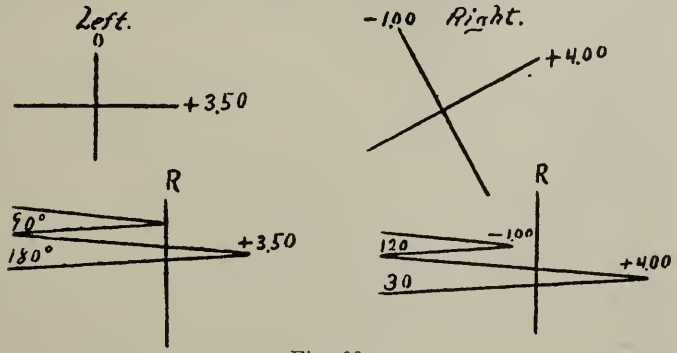


Fig. 38

The left eye shows (Fig. 38) the 90 meridian is normal, so we write for it a simple cylinder, + 3.50 ax. 90, because we must have the power at 180 and the power of cylinders is always across the axis. For the right eye we write — 1.00, which puts the 120th meridian on the line but drives the other 1.00 farther away so it must now have + 5.00 cylinder, ax. 120, hence the prescription will read — 1.00 + 5.00 ax. 120. That for the left eye shows simple hyperopic astigmatism, while the right shows a case of mixed astigmatism.

Another, — 2.00 — 1.00 ax. 180.

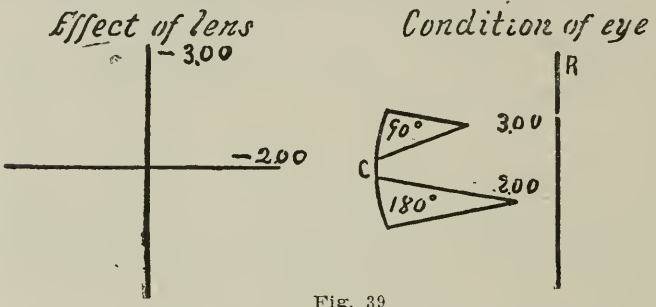


Fig. 39

Analysis shows the original to be correct and Fig. 39 shows compound myopic astigmatism.

Another, + 2.00 — 3.00 ax. 135.

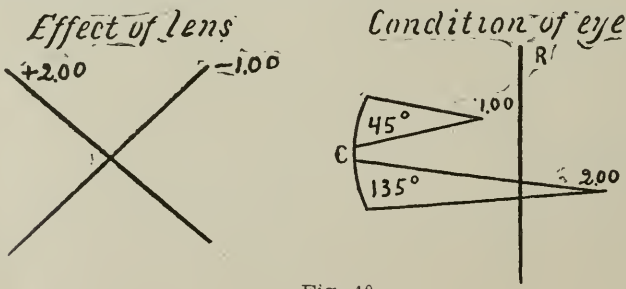


Fig. 40

Analysis, (Fig. 40) shows — 1.00 + 3.00 ax. 45, a case of mixed astigmatism.

Another, — 5.00 ax. 180.

Being a simple cylinder of course there is no transposition. A case of simple myopic astigmatism, Fig. 41.

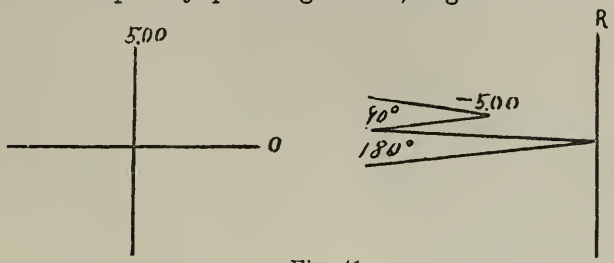


Fig. 41

Another, L + 1.50 — 3.00 ax. 155.
R + 1.00 — 1.00 ax. 180.

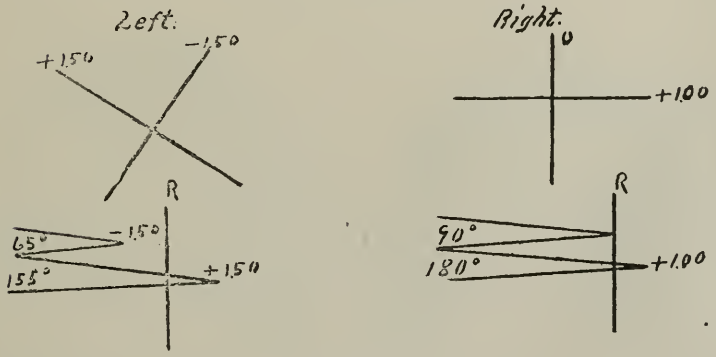


Fig. 42

Corrected, Fig. 42, L. — 1.50 + 3.00 ax. 65.
R. + 1.00 ax. 90.

Don't forget that transposing prescriptions and neutralizing lenses are two different propositions. In neutralizing, change signs but not axes. If — and + errors are equal, as in L., Figure 42, use — spheres and + cylinders.

THE EYES AS DOUBLE GAUGES.

How to Measure the Nerve and Blood Supplies Through Them.

The eyes are to the human body what the gauges are to boilers and electric plants. With an ophthalmoscope the doctor who knows how can look inside the eyes and observe both the arterial and venous systems, note the quality and quantity of the blood, thus learning what the blood-making and purifying organs are doing without inconvenience to his patient. There are many other things he may learn, too, as will be shown under the proper headings further along in this work. Few oculists, scarcely any physicians and no faith healers know the value of this simple little instrument. So simple, indeed, that an ordinary lens with one side plane, or slightly concave, is a very practical ophthalmoscope. The eyes are, therefore, the blood gauges of the body.

The doctor who knows how can apply dynamic and static tests through the eyes and measure the amount of the nerve supply just as perfectly as the steam gauge or amperemeter tells the pressure of steam or the quantity of electricity being consumed each day, hour or minute. Thus the eyes are the steam gauges and amperemeters of the body. No doctors, excepting my own pupils, have known this because I was the fortunate person who discovered it. I have compiled data, tables, etc., and named them "The Neurometer" (nerve measure). They will be found in the regular order of my story, and those who master them will find them so accurate that after a complete examination they can figure, very closely, the patient's age. If this sounds incredible, think what a fool I would be to make the assertion if it were not true.

The schematic eye, Fig. 44, is made to a scale, each five millimeters representing one, so that it represents an enlargement of twenty-five times, the regularly accepted dimensions for an ideal eye being:

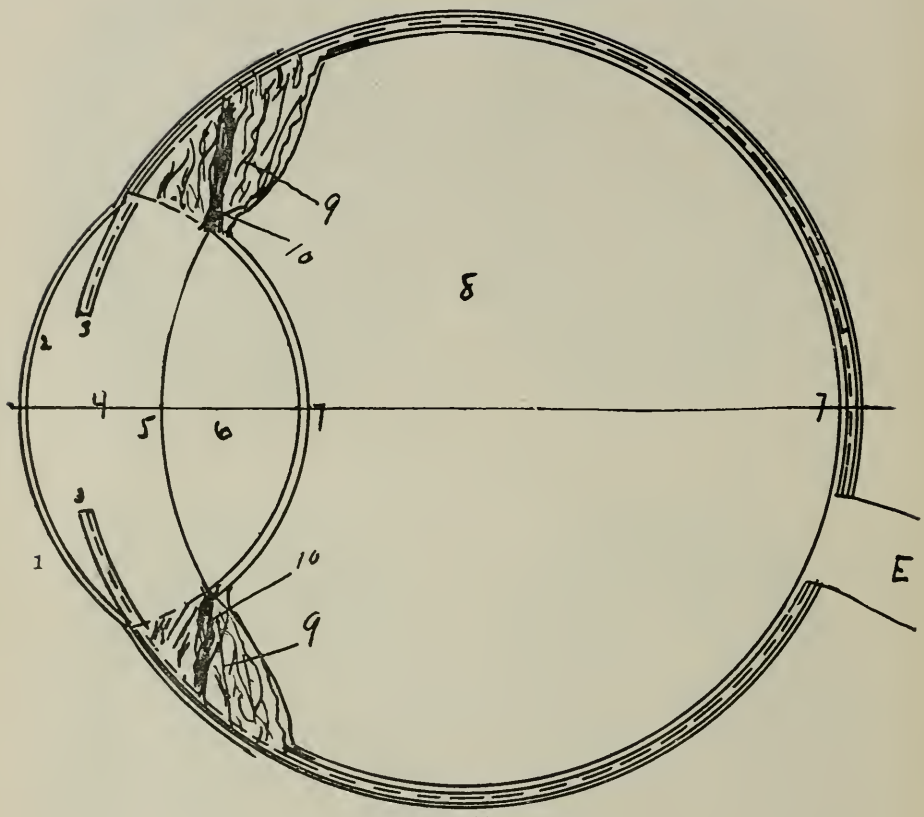


Fig. 44

Radius of curvature of cornea, 7.8 millimeters.
Distance of anterior of lens from cornea, 3.6 millimeters.
Radius of anterior surface of lens, 10. millimeters.
Distance of posterior of lens from cornea, 7.2 millimeters.
Radius of posterior surface of lens, 6 millimeters.

Distance of posterior of globe from cornea, 22.5 millimeters.

Radius of globe, 10.8 millimeters.

The normal eye is 9/10 in. long, 8/10 in. wide, 7/10 in. high, approximately 45. diopters power.

The reference figures indicate:

1. Conjunctiva: a delicate membrane composed of minute blood vessels and nerves with just enough connective tissue to complete the structure. It covers the front of the eye, as shown, then laps back inside the lids, forming a lining, and serves the double purpose of furnishing the soft surfaces, which, when lubricated by the tears, prevent friction from winking, and being highly sensitive, it protects the eye by giving quick warning of the presence of foreign substances. It is a great exaggerator, always declaring the smallest particle is a whole brick.

2. Cornea: the projecting transparent portion forming about one-sixth of the outer wall of the eye. It is of cellular structure with tough surfaces so nearly like horn that its name was given on account of the resemblance. It is transparent so light may pass into the interior, and its radius of curvature is shorter than the main globe in order to give the whole eye more focusing power, for remember in all optical literature curvature means power, and the sharper the curve the greater the power, consequently the quicker will rays of light focus after passing it.

3. Iris: the projections from the margin of the cornea; the space between the two figures represents the pupil, which appears to the observer as a black spot in all eyes. Some, even doctors, call it the "sight" of the eye. It is the hole in the iris or curtain, through which light must pass to get back to the posterior wall, where the "sight" spot is. The curtain is formed by combining a great number of straight ligaments with a circular muscle, and the whole thing would be like a lace curtain were it not for the pigment filling, represented by the dashes. This pigment gives it color; the more pigment

the darker the color. Close observation shows a variety of colors in the same curtain, hence the name iris, which means rainbow. If the nervous connections are normal it is under command of the retina, or optic nerve, and regulates the amount of light admitted. The ligaments run from the edge of the pupil outward, while the circular muscle, sphincter, it is called, being the only one supplied with nerves, reduces the pupil by contracting, thus pulling the inner ends of the ligaments together; or, enlarges it by relaxing its efforts. Some very ridiculous stories have been told about this curtain.

4. Aqueous humor: fills all the space between 2 and 5 and the iris floats in it. It is briny, cool and is rarely the seat of trouble—a good hint from Nature about salt.

5. Anterior capsule of crystalline lens: the posterior one is not numbered because the one figure is enough for both. They enclose:

6. Crystalline humor, which, while a liquid, is constructed in layers, nearly like an onion. The lens includes the capsules and humor and is held in position by a combination similar to that described for the iris, only larger and more powerful, for, instead of a hole, as the iris has, the lens is there to be operated, its power being increased by pressure around its edge which forces shorter radii of curvature. This function was intended for adapting normal eyes to near points. Rays from as far as twenty feet or more distant are so nearly parallel that the normal eye focuses them with very slight effort, but when they come from points nearer they are decidedly divergent, which forces the eye to increase its focal power if it would see distinctly. There is a little canal around the edge of the lens, which I call a bicycle tire, for simplicity of illustration, a hollow tube filled with liquid which makes it very elastic, especially in young and middle aged people; this tire is attached to or rather formed by the suspensory ligaments, and pulls against them almost enough to overcome them, but not quite, so that the lens remains at its lowest power except when the sphincter muscle comes to the aid of

the tire and accomplishes what is called accommodation for near points. When the necessity ceases the sphincter lets go and the suspensory ligaments pull the lens back to its original static or natural condition. As we grow older the tire's contents shrink so that it is no longer so elastic and the sphincter muscle, not being able to do all the work, fails to focus light from near points at the retina and glasses have to be used for reading on eyes which are otherwise perfect. As this is an incident of old age, it is called presbyopia. When you see people who, after using reading glasses for a while, also put some on for improvement of distant vision, you will know they never had perfect eyes, although they may have had perfect vision. The story of eyes "flattening" from old age is another story that isn't true.

7. Hyaloid membrane: a layer with a past. It originally entered the eye at "E" as a canal and passed straight to the center of the posterior capsule of the lens, carrying the material from which the lens was constructed; when that job was finished it expanded and enclosed the vitreous humor (8), which fills the globe. That this humor is nourished by way of the same old channel there can be no doubt, because when patients come complaining of floating specks we change their diet, when the specks disappear.

The layer next outside of the hyaloid membrane is the retina, comprising a network of nerves and blood vessels, the nerves being branches of the optic, or second cranial. Its function is to transmit impressions to the brain, and its structure is complex microscopically, which, however, is not a necessary detail of this part of my story. One of its layers, that of rods and cones, has to do with the next general layer, represented by the dash lines, which is of honeycomb-like structure, the cells being filled with pigment. This layer is for the purpose of receiving and absorbing excessive light, thus preventing injury to the retina which would interfere with vision. This layer also extends into the iris, giving it its color.

The next layer is the choroid: it carries the blood vessels

and nerves which nourish and furnish motive power to the sphincter muscles of the ciliary body and iris. The ciliary body is composed of folds of the choroid and is marked "9" in the illustration. This drawing shows the lower half of a right eye, as if it was bisected horizontally. The suspensory ligaments marked "10," radiate from the edge of the lens and are rooted firmly in the ciliary body.

The outside layer, extending from the cornea to "E," is the sclerotic (hard), a layer of protection, its structure being fibrous and tough; in it are inserted the six muscles which control the motion of the eyeball. All of these muscles have their origin within the orbits, the cavities in the skull in which the eyes are set; four of them pass straight up over, under and on either side branching out until they cover the whole eyeball almost to the edge of the cornea, their function is to move the eyeballs; the other two pass forward on the side next the nose, then turn and pass over and under the globe and a little obliquely backward. Their function is to prevent the eye from rolling on its axis, which is represented by the line drawn through the center. This line is called the optical axis; the old school books teach there is also a visual axis, which crosses this one obliquely, but that story is like many others by the same writers, decidedly oblique, as I will show.

"E" is the gateway through which the retinal vessels and nerves enter and emerge. In all eyes the space shown is not sensible to light impressions because the retina only begins at its edge, hence it is called the "blind spot." Outside of the space marked "E" is a zone in which the vessels which supply the choroid pierce the sclerotic coat, which has no vessels or nerves of its own. The spot marked "E" is on the inner half of the eye, but is half way between the top and bottom. The field around the posterior pole extending from the blind spot to an equal distance beyond the axis is more highly sensitive than other parts, because images of all objects seen clearly are formed there; this field has been considered important enough to be named, so it was called "macula," meaning "spot," and

a German who wanted to get ahead of his colleagues imagined he could distinguish a decidedly yellow color in it, and he added the word "lutea," meaning "yellow." His victims adopted his statement and have ever since reiterated the falsehood, thus affording opportunity for practical students to see how little such writers are worth as authorities.

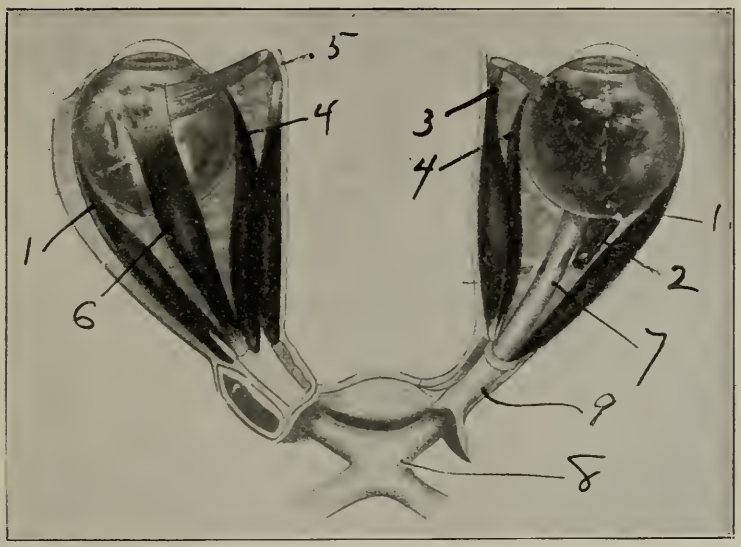


Fig. 45

Fig. 45 shows the relation between the two eyes and the arrangement of the muscles which arise from a cartilaginous substance in the orbits just behind the eyes.

1-1. External recti, operated by 6th nerves, turn eyes outward.

2. Inferior rectus, operated by 3rd nerves, turns eye down.

3. Inferior oblique, operated by 3rd nerves, prevent eyes

rolling inward at the top and outward at bottom, around axes.

4-4. Internal recti, operated by 3rd nerves, turn eyes in, associated automatically with accommodation.

5. Superior oblique, operated by 4th nerves, prevents eyes rolling inward at bottom and outward at top, around axes.

6. Superior rectus, operated by 3rd nerves, turns eye up.

7. The optic or 2d nerve, to the retina.

8. Optic nerve commissure, or switch-yard where the nerves cross over and divide; the macula of the right eye is supplied by the left nerve and that of the left eye by the right nerve.

9. Optic nerve sheath, for protection.

The lids or palpebrae, comprise superior and inferior tarsal cartilages areolar or connective tissue, the skin and the conjunctiva.

The muscles of the lids are:

Corrugator supercilli; 3d nerves; draw brows down and in.

Levator palpebrae superioris; 3rd nerves; lift upper lids. Originates with muscles of orbit.

Orbicularis palpebrarum; 7th nerves; to close lids.

Tensor tarsi; 7th nerves; press the edges of lids to globe, retaining and distributing lachrymal lubrication.

The Meibomian glands traverse the tarsal cartilages and connect with ducts to the free margin of the lids. They are most plentiful in the upper lids and their function is to carry off accumulations from the lachrymal fluid which penetrate the conjunctiva.

The lachrymal glands are situated at the upper outer angles of the orbits and supply fluid for lubrication. It passes away through the lachrymal canals, at the inner angles of the eyes into the nasal ducts.

The blood supply of the eyes and lids comes from the ophthalmic arteries, which are branches of the internal carotids, branches of innominate and left common carotid, branches

of the aorta, from the heart. It leaves the eyes through the ophthalmic veins to canals, in the base of the skull, which connect with the internal jugular, thence to the subclavian, innominate, superior vena cava and heart.

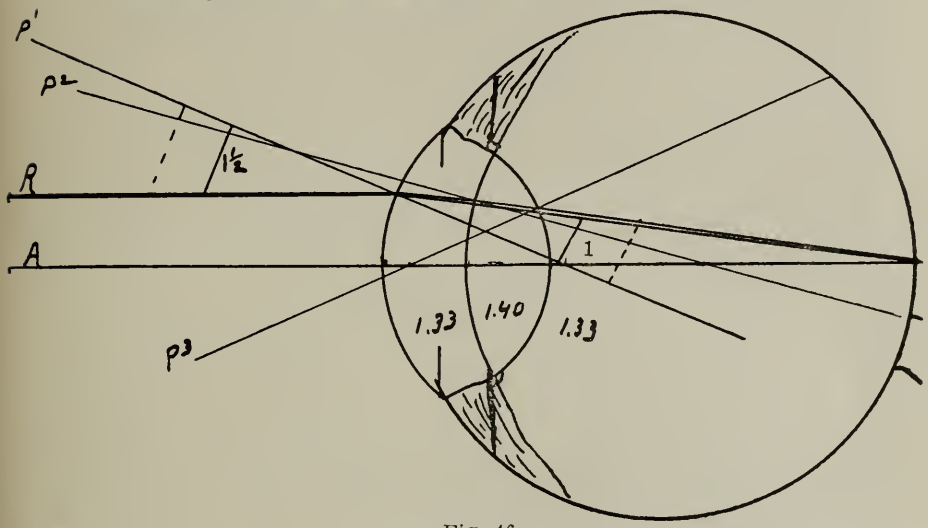


Fig. 46

Fig. 46 shows how refraction occurs at the cornea and at both surfaces of the lens. A is the principal axis, R is the ray approaching from infinity parallel with the axis, P^1 is the perpendicular to the cornea, P^2 the perpendicular to the anterior surface of the lens, P^3 the perpendicular to the posterior surface of the lens. Assuming that the entire eye is of one density and that equal to glass, index 1.50, the angle marked 1 1/2 outside and the one marked 1 on the inside would indicate the course to be on the lower line to the retina; as a matter of fact the ray follows the upper line, requiring three calculations to carry it through cornea and lens, but I have made both lines to show that as a time and work saver the

coincidence is a happy one, because either gives the same result practically. To make the real course the angle outside of the cornea is to the one inside as 4 is to 3 because the index of the cornea and aqueous is 1.33 1/3, while the air is 1.00; then the angle outside the lens, in the aqueous, is to that in the lens as 21 is to 20 because 1.40, the index of the lens, is to 1.33 1/3, the index of the aqueous, as these figures are to each other. It is found in this way; 1.33 1/3=4/3; 1.40=7/5; reduced to a common denominator the former is 20/15 and the latter 21/15. The larger angle being in the rarer medium the figures reverse, of course. Then in passing the posterior surface of the lens the angles are as 20 is to 21, the larger angle being in the vitreous humor. Make the drawing on a scale of 1 inch for a millimeter, according to the figures given on another page and the magnification will make the points clear.

This is called the static refraction of the eye because the muscles controlling the lens are at rest. As this eye focuses at the retina it must be emmetropic.

The alleged "old masters," who wrote works on the eyes, had a lot of idols they worshiped, for with them they were able to mystify their readers into accepting them as authorities because they were incomprehensible. Fig. 47 shows one of these idols, naked. The lines O ax are the optical axes because they pass from pole to pole through all the principal points; the lines V ax show what they called the visual axes. They insisted these were necessary because when the eyes are completely at rest the optical axes must be parallel, hence we would see double were it not for those visual axes which they described as secondary axes, necessarily. Of course their claim was purely theoretical, and, had they given the matter a second thought they would not have made it because no eye, emmetropic or hyperopic, can be at rest absolutely when looking at a distance for the reason that while, for the purpose of illustration, we assume the rays approach the eyes parallel when they come from infinity they are really a trifle divergent, and for the same reason that a pair of perfect eyes in looking at a

point 40 inches distant, accommodate 1.00 D. each and converge .50 each, they must accommodate for an 80-inch point .50 each and converge .25 each and for one mile each would have to accommodate 1/1600 of a diopter and converge 1/3200. In maintaining the ratio of .50 convergence to 1.00 accommodation for all points, near or far, it is clear that no

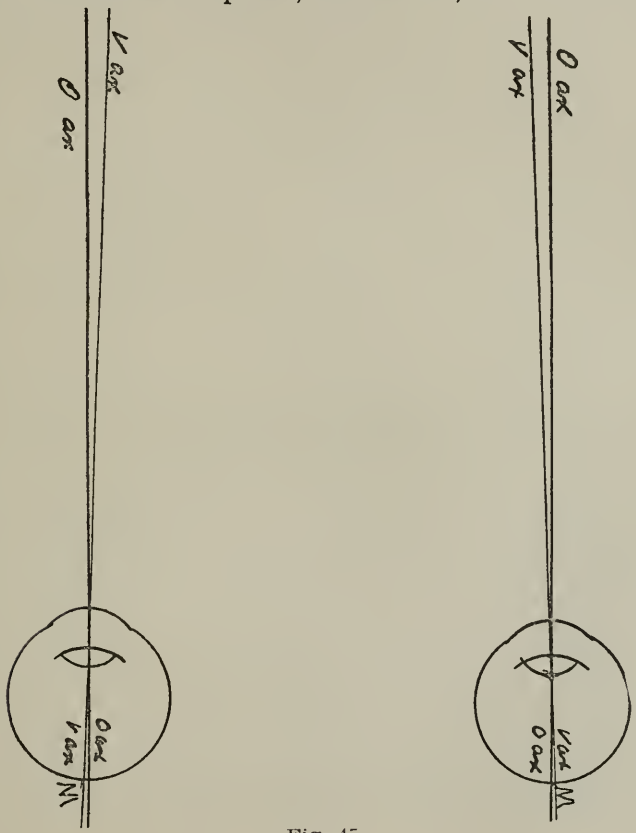


Fig. 47

separate "visual" axes are necessary, and if there were such things they would cause incoordination. Therefore, that story is on a par with the other one they tell about the displaced macula, as if it slipped around like a disjointed bone.

While we are breaking idols, let us smash another. Fig. 48 shows the line X V F as the visual axis; the line A O the optical axis; the line X C the "line of fixation"; N N the nodal points; the line N E the "major axis of the corneal ellipsoid," and C the center of rotation. They tell us the angle formed by the line of fixation and the optical axis X C A, is the "angle gamma," and that formed by the "visual axis" and the "major axis," X N E, is the angle alpha. That was certainly Greek enough for the most exacting (Landolt apologizes for it, explaining that his drawing is "very schematic"), but unfortunately it is a false proposition for the reason given with reference to Fig. 47 where it is shown that there is no visual axis separate from the optic axis, because none is needed, hence the smashing of the one idol kills the other.

The relation of accommodation to convergence causes trouble when there are errors in the dioptric systems of the eyes because the hyperopic eyes need the accommodation but not the convergence for distant objects, and they need more accommodation for near points than goes normally with the convergence necessary, while the myopic eyes cannot see at a distance because their far points are nearer than infinity, and when the object is brought near enough to see they need the convergence without the accommodation that normally goes with it, therefore, in both instances there is in-coordination. In the hyperope the ability to compensate or adapt the organs to the situation is supplied by way of the 6th nerves to the external recti which antagonize the interni to the extent of maintaining parallelism of the axes, so that binocular vision is afforded, but the strain on the nerve supply is enormous. Each diopter of accommodation being accompanied by .50 convergence, requires at least .50 negative pull via the 6th nerves, making the total demand on the nerve supply 2. D. Thus a

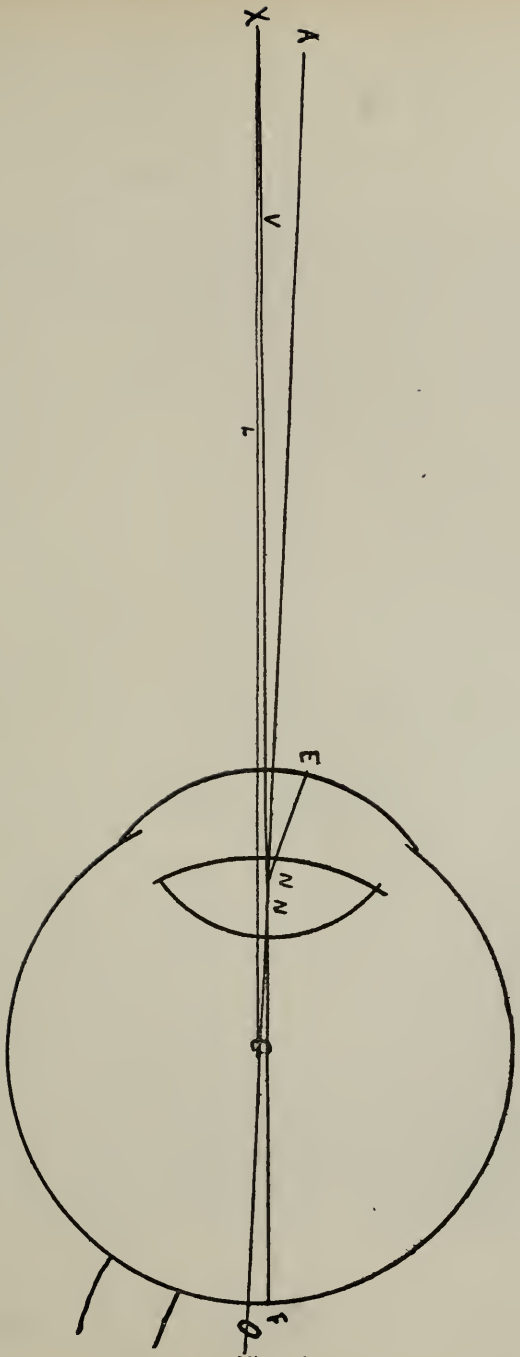


Fig. 48

hyperope of 1.00 D, each eye, has a 4. D. strain. Taking one second as the unit of time measure, 4. D. per second means 240. D. per minute, 14,400 D. per hour and 230,400. D. per day of sixteen hours. In order to realize fully what this means we must find out what the average demand is in the case of an ideal person, with normal eyes. An emmetrope, working at 13 inches for three hours daily, which is a fair average, would use 3. D. each eye for accommodation and 1.50 D. each for convergence, a total of 9. D. per second, 540. per minute, 32,400. D. per hour, 97,200. D. per day's work. At all other times the eyes are practically at rest. The eyes receive their supply from four and one-third pairs of nerves, and the work figured above only accounts for the branches of the 3d pair which operate the ciliary sphincters and the internal recti. As the other branches of the 3d, 2d, 4th, 6th and the ophthalmic branches of the 5th have comparatively nothing to do, and as we are unable to measure what they do, we think it reasonable to grant them enough to make the above figure 100,000, hence we charge 2.800. D. for them. Now, as these four and one-third pairs are 36 per cent. of the entire number of cranial nerves and 10 per cent. of the entire number in the body, and as any other four and one-third pairs will show one or two doing the chief work, we conclude it is not unreasonable to estimate the proportion throughout, and multiplying 100,000. D. by 10 gives a grand total of 1,000,000 D. daily as the average needs of the entire system, hence we assume that to be the average capacity. Of course overdrafts may be made occasionally without danger, but the constant drain caused by 1. D. hyperopia shows a daily excess demand of over 23 per cent. and for the purpose of easy calculation we call it 24 per cent. Thus 1.50 D. hyperopia would mean 36 per cent. excess; 2. D., 48 per cent.; 3. D., 72 per cent.; 4. D., 96 per cent. Above that there is comparatively little strain because the demand is so great there is little effort, except for brief periods. But we do find, as a rule, such cases are dull mentally, although quite hearty physically. When we know that hyperopic eyes are the

only organs in the body that can overcome their own defects, it is plain that the strain must be a factor in all the functional derangements such people suffer from. If they are astigmatic it is all the worse, because there is a constant effort to overcome that fault by accommodation and it cannot be done because that effort affects all meridians alike, the astigmatic error being in the cornea and the accommodation in the lens. No point being made on the retina by the effort, it is much like trying to climb a greased pole—lots of work but little result. This is why astigmatism causes more headaches than simple hyperopia does. If the astigmatic error is as much as 2. D. or more, it causes less trouble than the smaller amounts because vision is so bad there is little attempt to improve it.

Our critics, referring to the nerve strain calculation, say: "According to your own figures only 9.72 per cent. is actual measure and the rest is estimate." Yes, but taking the eyes alone, 97.2 per cent. is actual measure and all of the hyperopic strain is actual measure, while the estimated part is applied equally to both, so that by the law of ratios the conclusion is exact and must yield the same results no matter by what system the calculation is made. The neurometer was based on this calculation and it works. Our clinical analyses are based on these figures, and they work.

The hyperope, because of the constant activity of his accommodation, develops remarkable strength in that department, even while sacrificing other functions, and he naturally notices the disturbance elsewhere before he does in his eyes, because the extra current of energy only makes the eyes perform their functions normally while other sphincter systems throughout the body, which are normal, receive the extra current too, and it makes them overdo their work, with the result that there will be interference with the circulation of blood, there will be constipation, bladder troubles, the heart, stomach, lungs and muscular action generally will be insufficient or hypersufficient, and women will suffer menstrual derangements. But these are not all. The supply of energy in

the cerebellum being depleted, there will be a deficiency in the acid reactions in the stomach and elsewhere, the blood-making and cleansing organs will fail for chemical, as well as mechanical reasons, and then the whole body is subject to any or all the disorders flesh is supposed to be heir to. The abnormal strength of accommodation is also a source of anxiety on the part of the doctor who attempts to analyze the case, part of which analysis is measuring the amount of hyperopia, hence the necessity for a method of procedure which will enable him to overcome or circumvent spasms, tonic or clonic.

The need of such method is not limited to the hyperope, for the myope often has spasms from the incoordination of accommodation and convergence at near points, although his nerve strain is not great enough to set up other functional disturbances. A myope of 2.00 D. will rarely read farther away than six or eight inches, although, theoretically, he should read at twenty inches. The reason is that when he holds a paper at thirteen inches the convergence is necessarily 1.50 D. in each eye; this brings with it automatically 3. D. accommodation, which, added to his myopia makes his dioptric system 5. D., requiring the object to be at eight inches. When he puts it there the eyes must converge 5. D., or 2.50 each and this brings 5. D. accommodation in each eye, which, added to his myopia makes 7. D. and puts the first conjugate focus at five and one-half inches. By this time his accommodation, which is not so vigorous as the hyperope's, becomes exhausted and there is a harmony of accommodation and convergent points. But all this tends to make the accommodation active enough to fool any one who does not understand the physics and physiology of the proposition. Old time opticians fitted such people by having them hold a newspaper as far from the face as they could and read a line, then measuring the distance in inches and giving the number corresponding. They wondered why the purchaser returned complaining, but weakened the lenses time after time until they found comfortable ones. If their patrons developed stomach trouble and headaches later they

never thought the eyes had anything to do with it, nor did the wearers, who went to the doctors for medicine. Later in life they found they could see better with weaker glasses and could see at a greater distance with their naked eyes, hence the idea that the eyes flatten with age. This was corroborated, apparently, by the fact that hyperopes, who never wore glasses for distance until long after they had used them for reading, finally found they could use convex glasses to advantage for distance. This was because their accommodation could no longer overcome their defect. Even to-day some oculists will insist the eyes do flatten with age. There are also people who declare the earth is flat. The myope described above would have been given — 6. to begin with and gradually reduced to — 2.50 or 3. when he would have been hyperopic .50 to 1. and suffering nerve strain, where before he only lacked vision. An interesting test for such cases is to have a real myope, or a hyperope, made myopic by over-correction with + 5. or 6. D. spheres, hold a paper as far from his face as he can read, then interpose a pair of 5 or 6-degree prisms, bases in, and note how much farther he can extend the paper, thus proving that accommodation is automatic with convergence, because when the prisms stop the necessity for convergence the accommodation lets go too.

One of the infirmities of age is a loss of accommodative power, because the lens is held in suspension and at its static condition by a lot of straight ligaments which are almost overcome, in early life, by the antagonism of the bicycle-tire arrangement surrounding the lens, so that comparatively little nerve force is required, but as this tire loses its elasticity, from shrinkage of contents, it leaves more work for the nerves than they can do, hence the need of glasses for near work, even for emmetropic eyes. This is presbyopia. It is called total when the person accepts a lens equal to the full measure of the distance he works; thus if + 2.50 is accepted for work at sixteen inches he would be totally presbyopic, because he would never need any stronger glasses for that distance. This would be

called total presbyopia even if he could read at eleven inches with the same lenses thus exhibiting 1. D. accommodation. An emmetrope sixty years old would do that, and a hyperope of 1. D. seventy years old would do it.

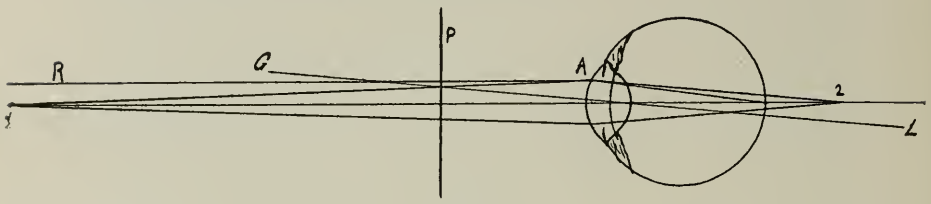


Fig. 49

The figure (49) shown herewith is an ideal eye in the matter of dimensions. From the center of the lens to the posterior pole is just the same distance as that from the centre of the lens to the line P in front of the eye. This line, then, represents the principal focal plane from which rays starting divergent would pass beyond the cornea and lens parallel with the axis. The ray R would be refracted and focus at the posterior pole because it approaches parallel with the axis. Now, while the eye is fixed on a distant object let another object be placed at farthest point to the left shown on the axis, which is just three inches. The ray from the point, which strikes the cornea at A would be refracted and pass away parallel to the line G L and would strike the axis at 2 if it could get there, as would also its fellow ray below the axis. But as neither can get past the retina, the circle of diffusion formed will have a diameter equal to the space between the two lines at the retina. This shows exactly what the circle of diffusion would be in a hyperope of 13.00 D. with accommodation at rest.

An interesting fact in this connection is that the circle of diffusion from the distant rays would be just as great if the eye was adapted to the three-inch point. The same is true of any two points. To make it plainer, if the eyes are fixed

on a point, say thirteen inches distant, rays from a point forty inches away would form circles instead of points. Then reverse the proposition and fix at forty inches; the rays from the thirteen-inch point would form circles of the same size. The first ones would focus before reaching the retina and the others would reach the retina before focusing. Of course if some critic wants to split hairs he would declare the rays that focus before reaching the retina will make a trifle the biggest circle, but I will anticipate him and reply that he fails to consider the increased angles of the rays from the nearest point which would increase the dispersion enough to offset the other.

There are a number of physical problems having reference to the eyes that afford physiological and metaphysical lessons which more than repay one for studying them. No one in practice pays enough attention to the laws upon which he works, whether it be physician or tradesman.

MEASURING ERRORS OF REFRACTION.

Cycloplegics Are a Humbug Suitable Only to the Oculists Who Use Them.

The emphatic assertions of some writers with reference to the value of cycloplegics are unwarranted by the facts. I assert as emphatically the drugs are not only worthless, but inconvenient and dangerous. I will tender a few reasons for my claims.

The chief reason is that not one in a thousand users knows how to use it, as is proved by their utter ignorance of how to tell when the accommodation is paralyzed; and if it is incomplete their method of applying lenses could not possibly do more than approximate the spherical part of the correction and very rarely even do that much with the astigmatism, hence Dr. Gould's assertion that "astigmatism is an elusive imp of mischief and it requires great keenness and patience to hunt him down. His hiding place is the ciliary muscle and his disguise amblyopia. He hates atropia as his father was said to hate holy water." Let one of the partisans of atropine instill the drug until he is satisfied the accommodation is at rest, then, if he can, let him fit his patient. When that is done, add + 3.00 for the 13-inch point. If the atropine is in absolute control there will be no difficulty in reading ordinary print, of course. Then let him direct the patient to hold the print as close to his face as he can read, measure the distance in inches, convert it into diopters and whatever it amounts to over 3.00 is the unsuppressed accommodation. If any demands greater proof than that he must apply to me personally.

Another reason is that anyone who really knows how to fit glasses can do it as well, or better, without a cycloplegic than with it, as will be shown in this chapter.

Another is that when the drug is used it partly disables one of our greatest allies in proving our work.

Another is that it causes great inconvenience to the patient, at least temporarily, and often permanently, if repeated too often—a common fault among users, who thus prove they are not sure of their work from the results of one test, else repeating it is dishonesty toward the patient.

Another is that after the work is done under atropine they dare not prescribe the full correction found because the patient cannot see well; hence their rule: "Under the age of twenty give one-fourth full correction; over twenty and under thirty, give one-half, and over thirty, give three-fourths of the full amount.

Another is that we want to show our patients exactly the conditions we are going to put them in at first, and why, then we have no difficulty, except when some wiseacre interferes, and we caution patients against all such.

Oculists merely treat eyes (most of them maltreat), while ophthalmologists use the eyes to measure the condition of the nervous system and must, of course, be able to measure their defects exactly without creating any unnatural conditions. For our convenience and to facilitate explanations, we classify the several cases we meet into the following:

First—Those with good vision.
Second—Those with medium vision.
Third—Those with bad vision.
Fourth—Cross-eyes.
Fifth—Those with spasm of accommodation.
Sixth—Those with asthenopia.
Seventh—Children and illiterates.
Eighth Old people.

Fig. 50 shows the proportions of the letters in the Snellen Test Chart. The patient being seated at 10, 15, 20, 30, 40, 50, 60, 80, 120, 160 or 200 feet from it should read the type corresponding to that distance, as marked on the card. The usual working distances are 15 and 20 feet. Visual acuteness is expressed in fractions, the numerator being the distance and the denominator the number of the type patient reads; thus,

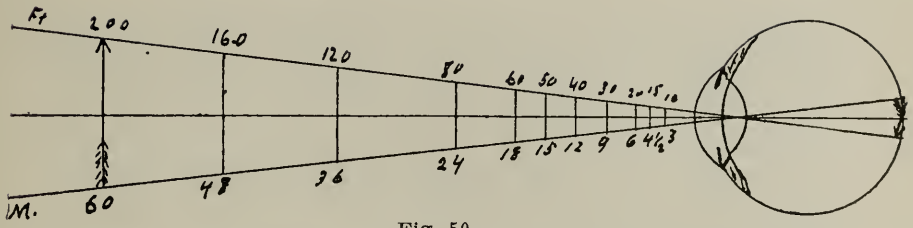


Fig. 50

if seated at 20 feet and number 30 type is the smallest that can be read without error, vision would be recorded 20/30; if number 20 is read it would be 20/20, which equals normal; if number 15 is read it would be recorded 20/15. Sometimes it is necessary to have the card only a few feet away; one eye may have 20/20 vision and the other only 2/200, that is, can only read the largest type at 2 feet. For very small rooms the 15 or 20 feet distance may be obtained by using a mirror and a card printed backwards so it will appear correctly in the mirror. In fitting eyes we look for:

First, + spheres.

Second, — cylinders.

Third, — spheres.

The only possible results are:

First, + spheres = simple hyperopia.

Second, + spheres, — cylinders = simple hyperopic astigmatism, or compound hyperopic astigmatism, or mixed astigmatism.

Third, — cylinders = simple myopic astigmatism.

Fourth, — cylinders, — spheres = compound myopic astigmatism.

Fifth, — spheres = simple myopia.

The second are the only ones that ever need correction by transposition. If the cylinder is weaker than the sphere it is really a case of compound hyperopic astigmatism and the prescription will transpose to a + sphere and + cylinder. If the cylinder is of the same power as the sphere it is a case

of simple hyperopic astigmatism and the formula will transpose to a simple cylinder. If the cylinder is the stronger, ever so little, it is a case of mixed astigmatism, but unless it is at least twice as strong as the sphere it needs transposing to get it into its simplest form.

A short way to transpose a prescription that needs it is: Take the difference between sphere and cylinder for the new sphere, then use the power of old cylinder, changing sign and exis. Thus the three possible cases above would be:

Original.	Transposition.
+ 1.50 — .50 ax. 180	= + 1.00 + .50 ax. 90.
+ 1.50 — 1.50 ax. 45	= + 1.50 ax. 135.
+ 1.50 — 2.50 ax. 30	= — 1.00 + 2.50 ax. 1.20.

We proceed, subjectively (tests with retinoscopes, refractometers, ophthalmoscopes, ophthalmometers, stigmatometers, etc., are merest guess-work), as follows:

First, Get the visual acuteness of each eye, separately, and record it. If it is normal it proves there is no myopia; if it is a line better than normal it proves there is hyperopia of at least 1.00 D. and that there is no astigmatism worth looking for; if it is not as good as normal it may be hyperopia with insufficient accommodation, or it may be astigmatism, or it may be myopia, or it may be the optic nerve is affected.

Second, Get the maximum power of accommodation and record it. If the patient's age is known and this is excessive, it indicates hyperopia, unless there are no evidences of nerve strain, when it may mean myopia, if vision was bad according to the first test.

Third, Test the muscle balance, which is really a static nerve test, with the double prism on one eye, adjusted so a light at fifteen or twenty feet appears as two, one above the other, and with a colored glass on the fellow eye. The colored light should be in line with and midway between the white ones. If it is , the nerve distribution is either normal or there is spasm in both the sixth nerves and internal recti branches of the third. In either case it is orthophoria. If the lights are

not in line it is heterophoria. If the colored light deviates towards the nose it is esophoria and means nervous spasm, exhibited in the internal recti, and it will also be found in the accommodation when we try the refraction tests. If it deviates from the nose it is exophoria and signifies weakness of the nerve supply, exhibited in the interni and of course it will be found in the accommodation during the refraction test, unless it be a clonic spasm, which will make its presence known very quickly. If the deviation is up or down in connection with either of the above, it is hyperesophoria or hyperexophoria and means the disturbance is more general. If it simply deviates up or down, it is hyperphoria, and means an erratic distribution of nerve force.

Fourth, Put in front cell of trial frame + spheres, just strong enough to blur vision until the largest type on the test card is seen dimly, then put the next weaker in the rear cell, remove the first ones and repeat the operation, using the next weaker at each change (unless the patient shows signs of spasm by not improving in vision with each change, when it is proper to cheat the accommodation by leaving the same lenses in

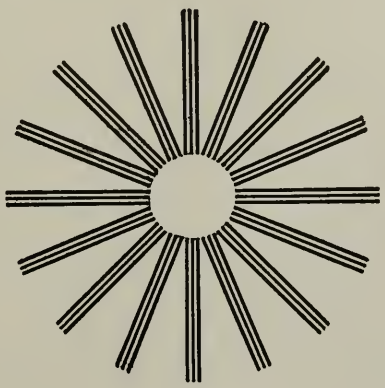


Fig. 51

while pretending to change), until vision is good enough so patient can pick out a few letters on the line he read easily without the lenses. Stop at this point and cover each eye, alternately, see if vision is practically equal. If it is not, put more + on the good eye, then continue as before until the same point is reached.

Fifth, Direct attention to the astigmatic chart, Fig. 51 is usually the best, and require the patient to tell which line, if any, is the plainest. If there is one, it indicates astigmatism and that the meridian at right angles to the plainest line is the one corrected by the sphere. To prove this, put the slot on that meridian and have him read the smallest letters possible, then reverse the slot and vision should be worse. If it is, hold weak — spheres in front of the slot, increasing the power gradually until vision is almost as good as in the other meridian; then substitute a cylinder of the power indicated, for the slot, placing the axis on the meridian where the slot showed best vision through the sphere. To test the correctness of the cylinder, first direct attention to the astigmatic chart and let the patient tell whether the lines are all equally distinct. If the ones which were plainest before are still most distinct the cylinder is not strong enough; if the opposite ones are plainest, it is too strong. If he says they all appear alike, reverse the axis, and if that spoils the equality of vision on the chart put its axis back where it was, refer him to the letters again and take a + .25 cylinder in one hand and a — .25 cylinder in the other, then try them alternately, the + first, axis on axis; if vision is just as good with the +, the — cylinder in the frame may be reduced; if it is not as good, try the — cylinder, and if it improves vision compare it with a — .25 sphere, when, if the sphere gives best vision, the original cylinder is proved. In the latter instance do not reduce the sphere, as appears to be indicated by the improvement in vision, but wait until the other eye is finished, when the accommodation may relax a little more, making reduction of the sphere unnecessary. There are cases in which the cylinder, being — .75

or less, may be stolen without impairing vision on the letters, although the astigmatic chart will not be perfect. The manner in which this is accomplished is to remove the cylinder from the trial frame, holding it in one hand and alternating it with a — .25 sphere in front of the eye, and if vision is best with the sphere of course the cylinder should be discarded; or, if a — .50 sphere gives better vision than a — .50 or — .75

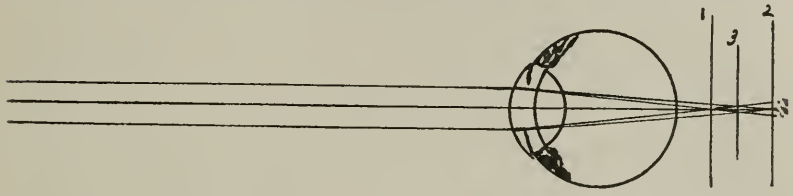


Fig. 52

cylinder, we often discard the cylinder. Fig. 52 shows the principle: Let the plane 1 show the focus of the vertical meridian and the plane 2, that of the horizontal meridian; the plane 3 shows where the circles of diffusion would form a round spot, but not a perfect focus. Suppose the hyperopia in the vertical meridian is 1.00 D. and in the horizontal is 1.50 D., + 1.25 sphere would put the plane 3 at the retina, the vertical meridian would be a little over-corrected and the horizontal a little under-corrected, but the saving of nerve strain would be five-sixths of the total, and vision would be as good as with naked eye. Such corrections are evidences of skill and judgment on the part of the operator.

If, in beginning the test for astigmatism, the patient sees no difference in the chart Fig. 51, it is not proof there is no astigmatism and the slot is used to find the meridian of best vision, when it is reversed and the proceeding continued as described above.

If, in proving cylinder reversing the axis spoils astigmatic chart but makes letters clearer, there is not enough + sphere. Increase before proceeding.

Sixth. After testing the other eye for astigmatism, both eyes are used to prove the spherical corrections. Cover the eyes alternately and proceed as per the last sentence in first paragraph of rule four.

Seventh. Get the maximum accommodation with correction on. If the patient is under twenty years of age and in good condition, it will not be any greater than at the first test, and probably less, because the glasses interfere with the limit-angle of convergence; if it is increased, it means the patient needs rest. Between twenty and thirty-five years the increase should approximate the power of the + spheres; if it is not so much, it means a good condition; if it is more, it indicates weakness. If the age is over about thirty-five but the patient is not yet presbyopic, the increase should be equal to twice the strength of spheres; if it is not, it means general weakness until after forty-five years, when it usually means presbyopia. If any patient has not been wearing constantly a correction of his errors of refraction and appears to need additional spherical power for close work under forty-five, do not give it, but require the correction worn constantly and rest from all work for a week or two when he will be able to do his close work without addition.

Eighth. To find the proper amount to add for close work, have patient hold a newspaper at the farthest point he expects to work, measure the distance in inches, take its equivalent in diopters, + spheres, and offer them, holding in front of both eyes at once, (be sure to hold them in good position over the other lenses); if he cannot read with them, reduce them .25 at a time until he can read dimly at the original point, then tell him to draw the paper to the usual position, when he will declare it perfect. This saves changing the reading glasses so often and insures best results from the lenses. If, as will be found occasionally, in cases where the hyperopia is so great that vision is poor even with best correction obtainable by the distance test, the patient requires an addition for reading of greater amount than the working distance represents, increase

the lenses for constant wear the amount of that difference. For example, a patient accepts + 6.00 for distance, but for reading at 13 inches + 4.00 must be added; it follows that as only + 3.00 is required by law the other + 1.00 must be added to the lenses for constant wear; they will be accepted readily, too.

Ninth. Test the muscle balance as before; the cylinders may be removed for this purpose because they are always —, but the spheres must remain. If the frame has three cells it is not necessary to remove the cylinders. If there was esophoria before and it remains to the extent of 1° to 3°, we know there is still .50 hyperopia concealed by a tonic spasm; if there is 4° to 6°, .75 hyperopia is concealed; if it is 7° to 10°, there is 1.00; if it is 11° to 13°, there is 1.50, and if it is 14° or more there is 2.00 D. concealed, and we add these respective amounts to the correction accepted, regardless of vision, because constant wear will cause natural relaxation, and when the spasm is broken we retest and make whatever changes may be found necessary to be exact. In many cases we are able to prove the correction at once by the use of the neurometer. For example, a patient accepted + 2.00 with 20/20 vision, showed an accommodation of 9.00 D., indicating 23 years, 4 months, by the neurometer; he showed esophoria of 2° by this test, so + .50 was added arbitrarily. Reference to the neurometer table of additions to age for hyperopia indicated 4 years, making 27 years, 4 months; then for his professional work, which develops the intellectual brain and makes the nervous system more responsive to demands, there was added 7 years, 6 months, making a grand total of 34 years, 10 months. He said he was 35 years, 3 months and 5 days. By changing our correction to + 1.75 he saw 20/20 well; adding the + .50 for esophoria, made + 2.25, for which the table says add 4 years, 5 months, 10 days to the showing by accommodation and profession. Thus 23 years, 4 months, plus 7 years, 6 months, plus 4 years, 5 months, 10 days, equals 35 years, 3 months, 10 days, and we decide to prescribe + 2.25

instead of + 2.50, which proved correct by later tests after his nervous irritation subsided.

Tenth. Nearly all cases should wear spectacles, at least until the nervous system recovers its normal status; it is essential for appearance as well as comfort that the measurements be taken properly and the prescription filled as written. A common fault among manufacturing opticians is they do not exhibit ordinary intelligence, or honesty, in their work; they take a pair of pliers and bend a nose-piece until it corresponds to the measures given, with the result that the patient looks like a caricature when he puts it on. They call this "prescription" work, which is a mistake.

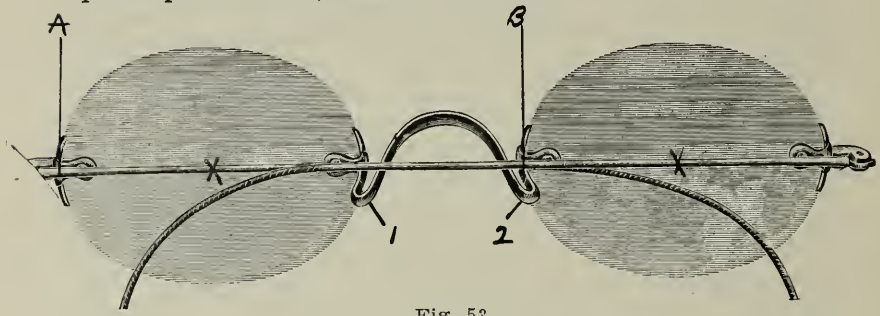


Fig. 53

Fig. 53 shows what is called a "saddle" bridge, or nose-piece, by opticians. The shanks extending from 1 and 2 to the lenses are for the purpose of changing the pupillary distances with a simple twist of the wrist; it is a convenient thing for the mechanic, and is not always hideous in its results because some noses require little or no change and it does fairly well, but there are a great many cases where the bend for the shank should be just where the temples cross the bridge in Fig. 53, and the spectacles shown in the cut would look neater on any face. They should be made "saddle," but more like the old-fashioned "C" bridge. Hoping that this may come to the notice of opticians, I suggest they adopt the

idea when a prescription comes with the injunction, "Make this bridge of as little material as possible." The intent of the saddle is to permit the operator to adjust a trifle if necessary. The optician should make frames to the measures, not bend to them.

The following measurements are all that are necessary: Distance between pupils, X to X, in Fig. 53, (to find it exactly in a pair of glasses, measure from A to B, in the cut), height of bridge from where temples cross, as shown in cut, to inside of top; width of bridge at base, 1 to 2 in the cut; position of crest or top of bridge with reference to a plane corresponding to the side of the lenses nearest the face; sometimes it is on the plane, sometimes back of it, and sometimes in front, the latter most rarely, the object being to regulate the distance of the glasses from the eyelashes. The angle of the crest of the nose will take care of itself if the optician follows my suggestion with reference to the shanks; it is a law of nature, (as absolute as is the law of nonspherical curvatures, that the two principal meridians are always at right angles to each other). The temple distance is not measured, but is regulated by the size of the lenses. A very small face would require 1-eye lenses, while a very broad one would need 0000-eye. The length of the hook temples should be given, and make them so long that the ends are just concealed by the lower part of the ears as the observer stands in front. Great discomfort results from making them too short.

Have a set of frames as follows for convenience in fitting:

		NOSE.			
Size of Eye.	P. D.	High.	Wide.	Crest.	Temples.
1	2⅛	1-16	½	1-16 Back	Short
0	2¼	⅛	9-16	On plane	Med.
0	2 5-16	3-16	¾	On plane	Long
0	2⅜	⅛	⅝	On plane	Long
0	2⅜	⅛	⅝	⅛ Back	Long
00	2½	1/16	⅞	⅛ Back	Long

If skeleton lenses are wanted, order a size larger than the fitting frame.

If eye-glasses are wanted, they should be of the same size as the fitting frame.

The foregoing applies to the first and second classes enumerated at the beginning of this chapter, except that for the second class it is usually best to take each eye separately all the way, except in the final proving of the spheres. In doing this unfog with — spheres .25 and .50; then .50 and .75; then .75 and 1.00, etc.

The third class is seldom difficult if there is any vision at twenty feet. If there is not, move patient closer until two or three lines of the test type are visible, then try the pin-hole disk and if it improves vision there is just that much encouragement. Next try the slot, whether the pin-hole improves or not. If one meridian is better than the other, leave the slot there and put such strong + spheres in the rear cell that they make vision worse, then neutralize gradually with — .25, — .50, etc., until the vision is as good as it was through the slot without the lens. Put in the + spheres indicated, if any has been accepted, then reverse the slot and vision should be worse. First offer + spheres in front of the slot and if they are accepted, with improvement of vision, continue increasing until the best possible vision is obtained, then give enough more to blur to the top line and neutralize away as before. If + spheres are not accepted, try —, and when that meridian sees as good as the other, stop and put on the cylinder indicated, prove it and proceed to get vision as good as possible by weakening the + sphere if necessary. In other words, find the best meridian if there be one, which locates the two principal meridians. Use the slot to isolate all but one at a time and treat it as simple hyperopia or myopia. Then put the results on a cross, diagram them and write the prescription, put it on the patient and prove it.

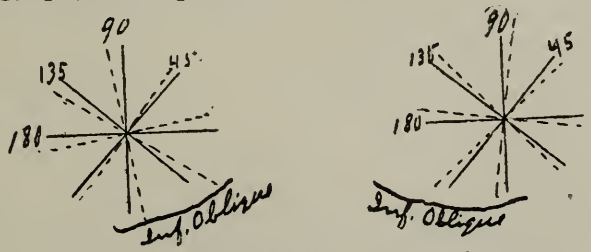
The fourth class is so important in many respects that a chapter has been devoted to it, which see.

The fifth and sixth classes need temporary sphericals. The fifth should be fogged to 20/80 as a rule, until the spasm breaks down, while the method described in connection with Fig. 51 is best for the sixth.

The seventh class children can often read the letters and is comparatively easy, except that nearly all have a clonic spasm of accommodation and must be handled carefully. Illiterates are comparatively easily handled by using the clock-face chart, fogging at twenty feet until the chart blurs, then unfogging until it is clear. If there is astigmatism so that patient sees one line plainest, fog and unfog until the opposite line appears plainest, then put in the + sphere indicated and finish with — cylinders, axis opposite the black lines. Unless there is much astigmatism do not correct it. If addition for reading is necessary, let patient be the judge of what is best.

For the eight class permit 20/20 vision with distance glasses, and add all the spheres they will accept for the near work. Remember in adding for reading the cylinder is not changed. Increasing the sphere gives what the eye needs.

It is not unusual to find people wearing glasses with the axes of cylinders at oblique meridians, when they should not be so. This is because they were fitted by novices or dogmatists who did not know the first principles of anatomy and physiology, physics or practice.



R Fig. 54 L

Fig. 54 shows a case in which there is irritation of the general nervous system to the spasm stage. It is exhibiting in

the third nerves' branches to the inferior oblique muscles of both eyes, with the result that they pull enough to rotate the eyes fifteen or twenty degrees or more, so that the two first principal meridians, 90 and 180, and the two second principal meridians, 45 and 135, are moved to the dotted lines, and the operator, believing it was true oblique astigmatism, fitted the cylinders to those meridians. The spasm is also present in the other branches of the third nerves which operate the lenses and much of the hyperopia is concealed. In such cases I have found invariably that not over one-half of the hyperopia was corrected. It is often possible to take these and, while the axes are found oblique when correcting each eye separately, to shift both to 90 or 180 or to the second principal meridians at the moment of permitting binocular vision, thus securing comfort and settling the question at once; but as a rule it is better to prescribe temporary spheres until the nerve supply measures o. k., then it will be discovered the obliquity has disappeared.

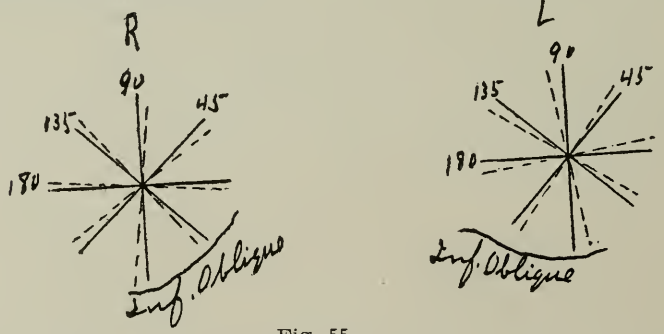


Fig. 55

The same is true of the reverse condition as shown by Fig. 55, when the stage of collapse is reached and the nerve supply being weak allows the inferior oblique to slack up too much. These cases are easier to control than the first class, but caution is always the better part in doubtful cases.

THE NEUROMETER.

Method by Which We Prove the Accuracy of Our Analyses.

One of the best ways to study a subject is to fix an ideal, then compare the real with it and keep statistics. This is the method I practiced in constructing the Neurometer (nerve measure). Prof. Donders printed, many years ago, the following table of accommodation, to show how it weakens from youth to old age and used it as a basis of calculation for the power of glasses for presbyopia.

10 years,	14.00 D.
20 years,	10.00 D.
30 years,	7.00 D.
40 years,	4.50 D.
50 years,	2.50 D.
60 years,	1.00 D.

He claimed that after 40 years, when the person with 4.50 D. accommodation, or less, used 3.00 D. for reading at 13 inches it took so nearly all that the eyes soon tired. Of course, it was the nerve supply in the cerebellum that gave out, but it exhibited in the eyes, so he was partly right; but he was mistaken in another important particular; he often prescribed more than + 3.00 for work at 13 inches and because the patient could see distant objects perfectly without glasses he assumed there was emmetropia, hence his table of numbers for glasses to be used at different ages in presbyopia is wrong, for any eye that is emmetropic will focus parallel rays at the retina without accommodation, hence would never need more than + 3.00 for 13 inches. Or, an ametrope, with exact correction, will never need more than + 3.00 added for work at 13 inches. He will not need all of that when he begins to require addition for reading, as he will be able to do some of the work for a long time.

However, the professor's table gave me an idea for which

I am duly thankful, and I elaborated it into an ideal standard for ideal persons with ideal eyes. It is assumed that the ideal day's near work amounts to three hours' actual application at about 13 inches. On applying this standard to several hundreds of cases I found many persons work more than three hours at close work, and such were invariably older than the table indicated for their accommodation, so I made allowances for the extra development from the extra work as will be seen. Then I found that hyperopes, whose accommodation is constantly at work during waking hours, also showed over-developed power in the eye department, even when they exhibited weakness in other parts of the body. This necessitated more allowances, not only for the hyperopia, but for extra hours' work at near points and for the effects of the extraordinary demands upon the nerve supply as found by examinations and tests, all of which follow and have been proved abundantly by myself and my pupils, who understand my methods of taking measurements.

For the dynamic test we use the ordinary type in vogue with the daily newspapers of our time, have the patient read aloud, holding the paper as near as possible to read a line by straining. We measure the distance from paper to the principal plane of the eye, which is at the apex of the cornea, and express the amount in dioptres.

For the static test we use a double prism before one eye and a red glass before the other; it makes no difference which eye the red glass is on, but I put it before the eye nearest to me. The three lights should be in a vertical line, the red, of course, in the middle. If the red deviates toward the patient's nose it indicates a + impulse, that is, an irritation of the nervous system to such an extent that it is in a state of tonic spasm throughout the body. We know by this there is not only hyperopia but that the spasm of accommodation is so great we will have a fight to control it, and, after we have made the refraction test and got on all the + we can, if the static test repeated shows the + impulse remaining we have proof

we did not get all the hyperopia—the neurometer tells how much is lacking. If the red light deviates from the nose it indicates a — impulse, or exhaustion of the nerve supply to such an extent that as soon as the eyes are thrown out of gear (which is practically what the test does), it exposes the truth even if the dynamic test deceived us. We know then, that there will not be a great deal of resistance during the refraction test, although we are equally as vigilant as when dealing with a state of irritation; and if the static test, applied after correction shows some deviation or none, the neurometer tells what it means and what to do. If the red light deviates toward or from the nose and above or below the mid-line between the white lights, it indicates an erratic nerve distribution as well as the + or — impulse; or, if the red deviates up or down, but neither to right or left, it indicates an erratic state of the nerves, either clonic or tonic spasm. The static test is of no use on one-eyed or cross-eyed people.

Four points are worthy of especial mention in this connection: First, our + impulse is esophoria, that is the eyes tend inward from spasm of the nerve supply, exhibited through the internal recti muscles of not one but both eyes. My opponents, who claim the eyes deviate opposite to the direction the lights are seen, call it exophoria, meaning eyes turning outward. Second, our — impulse is exophoria, eyes tending outward from weakness of the nerve supply exhibited through the internal recti muscles. My opponents call this esophoria by the same token they call the other exophoria. They also declare the eyes turn in from weakness of the external recti muscles and turn out from weakness of the interni. Third, they say muscles are at fault when there is deviation with the test on, even if the patient controls the two eyes and holds them in perfect balance with the test off, which is nearly always the case. I say it is the nerve supply away back in the cerebellum which is at fault. They operate and if the nerve supply is sufficient to overcome the damage, they claim a victory for operation; if the nerve supply is insufficient to act

properly, in spite of the operation, they admit no blame, but the victim has troubles galore. I never operate and always have good results. Fourth, the amount of prism required to set the red light in the middle is not the measure of the degrees of deviation, but is an indication of the intensity of the spasm if prism required is base in, or of the extent of the exhaustion if it is base out. The prisms are merely artificial substitutes for the natural impulse which is supplied under the direction of the controlling center in the brain, when the test is off. I would give a patient half a dozen grains of strychnine as quickly as I would a prism for constant wear. See chapter on prisms.

THE NEUROMETER.

Near Point.	Diopters.	Age. Years.	Months.	Days.
2¾ in.	14.00	10	0	0
3 "	13.00	12	6	0
3¼ "	12.00	15	0	0
3½ "	11.00	17	6	0
4 "	10.00	20	0	0
4½ "	9.00	23	4	0
4¾ "	8.50	25	0	0
5 "	8.00	26	8	0
5¼ "	7.50	28	4	0
5½ "	7.00	30	0	0
5¾ "	6.75	31	0	0
6 "	6.50	32	0	0
6¼ "	6.25	33	0	0
6½ "	6.00	34	0	0
6¾ "	5.75	35	0	0
7 "	5.50	36	0	0
7½ "	5.25	37	0	0
8 "	5.00	38	0	0
8½ "	4.75	39	0	0
9 "	4.50	40	0	0
9½ "	4.25	41	3	0

10	"	4.00	42	6	0
10½	"	3.75	43	9	0
11	"	3.50	45	0	0
12	"	3.25	46	3	0
13	"	3.00	47	6	0
14	"	2.75	48	9	0
15	"	2.63	49	4	15
16	"	2.50	50	0	0
18	"	2.25	51	8	0
20	"	2.00	53	4	0
22	"	1.75	55	0	0
26	"	1.50	56	8	0
32	"	1.25	58	4	0
40	"	1.00	60	0	0

If our patient is an emmetrope but works extra hours over the average three upon which this table is based, we would add to his showing by the dynamic test:

For 6 hours extra, 10 years, 0 months.
For 5 hours extra, 8 years, 4 months.
For 4 hours extra, 6 years, 8 months.
For 3 hours extra, 5 years, 0 months.
For 2 hours extra, 3 years, 4 months.
For 1 hour extra, 1 year, 8 months.

If the patient is a hyperope and is working extra hours, too, it is evidently just that much worse for him, so we figure the extra hours equal to more error, thus:

6 hours extra equals 1.00 D. more hyperopia.
5 hours extra equals, .75 D. more hyperopia.
4 hours extra equals .75 D. more hyperopia.
3 hours extra equals .50 D. more hyperopia.
2 hours extra equals . 50 D. more hyperopia.
1 hour extra equals .25 D. more hyperopia.

For intelligent people who apply themselves diligently, thinking and reading, we add from 5 to 10 years for the mentality and its effect on the accommodation.

All calculations where errors of refraction exist must

include the following table with variations, unless especially exempted:

ADDITIONS FOR HYPEROPIA.

For 1.00 D.	add	10.....	0..... 0
For .75 or 1.25	"	8.....	9..... 0
For .50 or 1.50	"	7.....	6..... 0
For 1.75	"	6.....	3.....0
For 2.00	"	5.....	0..... 0
For 2.25	"	4.....	7..... 0
For 2.50	"	4.....	2..... 0
For 2.75	"	3.....	9..... 0
For 3.00	"	3.....	4..... 0
For 3.25	"	3.....	0.....20
For 3.50	"	2.....	9.....10
For 4.00	"	2.....	6..... 0
For 4.50	"	2.....	3..... 0
For 5.00	"	2.....	0..... 0

This table is subject to alterations for conditions found by the examinations and tests:

First, if the static test, without glasses, showed a + impulse and it remained after the correction of the errors of refraction, we would increase the spherical part of the correction + .50 for 1 to 3 degrees, increase the spherical part of the correction + .75 for 4 to 6 degrees, increase the spherical part of the correction + 1.00 for 7 to 10 degrees, increase the spherical part of the correction + 1.50 for 11 to 13 degrees, increase the spherical part of the correction + 2.00 for 14 to 18 degrees, regardless of the vision, because the showing indicates spasms of the nervous system which are concealing approximately that amount of hyperopia, as the results after wearing constantly for a few weeks will show.

Second, if the static test, with correcting glasses on, showed a — impulse, we would not add as much to the age for the error as if there were no symptoms of breaking down in the nervous system:

For 2 to 4 degrees we would deduct 25 per cent.

For 5 to 8 degrees we would deduct 50 per cent.
For 9 to 12 degrees we would deduct 75 per cent.

Then there are other things to make allowance for, such as partial presbyopia, previous corrections of errors of refraction, — or partial corrections, and other features of the case not exhibited by the static test but by the patient's story, by the ophthalmoscope, by the general appearance, etc. Sometimes there is not enough in one symptom to warrant much allowance, but the total showing does, so we make it that way. This is a point which is difficult to make clear except by personal instruction, over clinics. However, the bright student will catch the idea and soon work it out himself.

As a safe and simple basis to work on, we take the dynamic test, with the correction of errors of refraction, and add to its showing the amount indicated for the hyperopia (we make no addition if there is myopia), then if the patient is younger than he figures, his condition is below the standard of the class to which he belongs; and if he is more than half way to the showing by the first table he is below the danger-line. Any person who is younger than the first table indicates is practically dead and will need the undertaker very soon.

For example, a patient requires a correction for hyperopia of 1.50 and, with that correction on, shows, by the dynamic test, 8.00 D; we refer to the first table and find the age 26 years, 8 months, and adding 7 years, 6 months, for the error, as required by the other table, gives 34 years, 2 months, as the standard of his class; if his real age is below that he is on the down grade; if it is more than half way down to 26 years, 8 months, he is below the danger line; if he is below the lowest age given it is a hopeless case.

The whole object in figuring out the ages without the aid of the patient is to place the true value on the symptoms found and to prove to ourselves and the patient the accuracy of our system of analysis.

The relation between the dynamic and static tests and the

correction of errors of refraction affords a nice little lesson in delicacy of work: First, the dynamic test being voluntary, the patient is liable to deceive us, so the static or involuntary test follows and if they dispute each other we believe the static, because all positive impulses induced by the defects in the eyes are removed, except when there is tonic spasm; even then we have either the positive exhibit by the static test or there will be so much pain in the eyeballs that we are not in doubt. Second, the dynamic and static tests, with the subordinate ones are constant checks on each other. Third, in persons under 20 years we expect to find great power by the dynamic test whether they are a little weak or not, but if the dynamic test with the correction on shows more power than it did before, we have proof of weakness sufficient to require absolute rest as a part of the treatment, because the near-point of convergence is so close to the face that the limit-angle is reached at the first test. We add the power of the lens to the showing by the first test to get the full dynamic power because the patient must have been accommodating just the amount of the hyperopia more than he showed at the first test. Between 20 and 35 the dynamic test should show exactly as much more power with the correction on than before, as the lens represents; if he shows less, there is either a mistake in the test or he is in excellent condition—which we would usually be inclined to doubt from the fact that he came for help—but if he shows a greater increase than the lens amounts to it is proof that he is in a weak condition. After 35 until presbyopia begins, the dynamic test should show an increase with correction on equal to at least twice the strength of the lens used; if he does not, it is either weakness from causes requiring rest as a part of the treatment or from presbyopia, and we are able to tell which it is by the general showing. No one under 45 should be presbyopic and if we find one we always order rest until he recuperates, when he will not need reading glasses if he will wear his correction constantly—and if he does not he will wish he had when the consequences arrive.

He will not be able to secure comfort with any glasses. After 50 presbyopia comes gradually, requiring occasional changes of the reading portion of the glasses, until the full dioptric number for the working distance is accepted, when no more changes will be necessary. After this point is reached the dynamic test will not work until, after completing the correction of the errors of refraction and adding + 3.00 for reading, we require the patient to hold the paper as near to his face as he can read a line, take the measure in inches, express it in diopters, just as in all other cases, but we must deduct the 3.00 we supplied; the remainder will be the showing by the dynamic test, and we get his age from the first table, adding nothing for his error, unless he has worn a correction many years; and even then we would be more liable to add something for his intelligence and education than for any other reason. Fourth, in beginning an examination, when we try the dynamic test, if the patient shows the power of a younger person, according to the first table, we diagnose hyperopia and a vigorous nervous system; but if the static test, which follows, shows a — impulse, it tells us the nerve demand has weakened the supply, and, at worst, we will only have to contend with a clonic spasm; if the static test shows nothing there may be either tonic spasm or neurasthenia and only the complete examination will settle the question; it is very rarely, however, that the dynamic and static tests fail to tell their stories, and as I have said, the other tests tell which is right when they differ; I may add that when they do fail we still have the others to help us.

The neurometer is not only an invaluable aid in analyzing the condition of the nerve supply but by it we are able to ascertain the seat of the primary cause with reference to whether it is mental or physical or both.

Case 1. G. A. M.; a Swede; mechanic; neurotic temperament; height, 5 ft., 9 in.; weight, 130 lbs.; history of malnutrition as child; varicocele since seventeen years old, for which he was operated on six weeks previous to examination; appear-

ance, anaemic and neurasthenic; habits, good; diet, —, without much appetite; dynamic test, 6.50; static test, 2° —; vision, L. 20/20 R. 20/15; correction, L. + .75 R. + 1.00; dynamic test, with glasses, 6.50, static test, with glasses, o. k. The fact that the dynamic test, when repeated shows no increase with correction on, indicates powerful control of his accommodation, with a tendency to clonic spasm, so we regard it as a + symptom. We analyze his case as follows:

Dynamic test, 6.50 = 32 years; as left eye fixes, add for + .75, 8 years, 9 months; for mentality, 10 years; total, 50 years, 9 months.

This gives a range between the accommodation of an emmetrope at 32 years, and that of G. A. M. amounting to 18 years, 9 months, the mid-point between the two being 41 years, 4½ months. If he is above it he is in pretty good shape to win perfect health. Speaking strictly physically, if he is above 40 years, 9 months, he is in good shape and if below 40 years, 9 months, he is in bad shape, but not dangerous unless he is as young as half way down to 32 years, which would be 36 years, 4½ months. Speaking strictly mentally, he must not be less than 40 years, 9 months, or he would collapse; while his maximum possibility is 50 years, 9 months; the mid-point between these two is 45 years, 4 months, 15 days, which we will assume to be his age on account of + symptoms found; if he is older he is in better shape than we figure him; if he is younger he is in worse shape than we figure him, and we will be governed in our prescription by the result of this calculation. A shorter way to make the same calculation, so far as practical results are concerned, is to take his 6.50 D accommodation, which equals 32 years, by table No. 1 of the neurometer, add for the error in his fixing eye 8 years, 9 months, as per table No. 2, less 33 1-3 per cent for his history, leaving 5 years, 10 months, then split the difference between the minimum (5 yrs.) and maximum (10 yrs.), adding 7 years, 6 months for his mentality, making a total of 45 years, 4 months. He was on the date of examination 45 years, 4 months, 11 days old;

showing by the first calculation, four days to the bad, and by the second calculation eleven days to the good. All of which proves the greatest drain on the nerve supply has been in his mental department. Part of it is accounted for by his abilities as a mechanical inventor and part by the trouble from which he suffered so long.

Case II. Dr. Walter, an oculist, practiced for twenty years; history, indigestion, headaches and "catarrh" of gall bladder; difficult to get story as he insisted on ridiculing the neurometer, and afterwards beat the college out of a son's tuition fee; arteries, o. k.; veins a trifle dark; dynamic test, 4.25; static test, 4° — impulse; vision, L. 20/30, R. 20/20; never wore glasses and declared he had no defects in his eyes; correction, L. + .50 + .50 ax. 90; R. + .50 + .50 ax. 90; dynamic test, 5.25; static test, 1° —. The neurometer indicates 37 years for 5.25 D. accommodation and his meridian of greatest hyperopia was 1.00 D., for which we add 10 years, because his — symptoms were offset by the + symptoms, making him 47 years old. The examination was made on the 18th of December, and one of my pupils who did it, threw off one month for the 1° — symptom by the static test, after correction, so that it figured 46 years, 11 months, and as the patient admitted he would be 47 January 24th, the calculation showed him to be six days to the bad. Note: We add nothing for his mentality. He had none worth mentioning.

Case III. M. C., teacher; temperament +; appearance, healthy; complained only of tired feeling and sleepiness when trying to do close work; formerly had dyspepsia, headache, catarrh; had worn glasses many years, which proved the proper correction; dynamic test, 1.75; static test, 7° — impulse; correction, + 2.50 + .50 ax. 90, each eye; dynamic, 5.25; static test, 4° — impulse. In this case, glasses having been worn constantly, and the dynamic test showing less than 7.00 D., we suspected presbyopia, which was corroborated by the fact that the increase in the showing, by the dynamic test, after correction was only slightly greater than the amount

of the error in the worst meridian; that he was short on nerve supply is shown by the static — impulse after correction and by the fact that he accepted readily + 1.50 addition for close work. The fact that he had been wearing his correction several years, thus being practically an emmetrope, made it necessary to make calculation as follows: He worked at a near point about nine hours daily, six of which are extra, for which the neurometer says add 10 years to his showing, because, under such conditions the nerve demands about equal those of 1.00 D. hyperopia, but we deduct 25 per cent for — impulse by the static test and 25 per cent for partial presbyopia, leaving only 5 years to be added for his close work. His 5.25 D. accommodation showed 37 years, to which was added 3 years, 4 months for his error, and 5 years for extra work, making him 45 years, 4 months on the date of the test, and he was 45 years, 4 months, 28 days, or 28 days to the good. His mentality was figured in his extra hours' work.

Case IV. Miss B., clerk; appearance, fairly good; complaints, dysmenorrhœa, headaches, difficult urination, up a dozen times nightly, and more often during the day; hyperopia, 3.25; dynamic test, 4.00 D. before correction and 7.00 D. after; static test, 4° — before and 4° — after; her accommodation after correction indicated 30 years, her error called for 3 years, 1 month, 15 days to be added, and, on account of the + symptoms shown in the general examination no allowance was made for the — ones except to add the minimum for her work, which is 5 years, aggregating 38 years, 1 month and 15 days. She was 38 years, 3 months, thus showing 45 days to the good.

Case V. Father B., priest; appearance, fair; complaints, catarrh, indigestion, headaches; dynamic test, 8.00 and 9.00; static test o. k.; error, hyperopia, 1.25. The neurometer shows 23 years, 4 months for his accommodation; 8 years, 9 months for his error, and the minimum of 5 years was added for profession to allow for his — symptoms, which were not serious, inasmuch as he did little close work; total, 37 years, 1 month; he was 37 years, 2 months, 17 days.

Case VI. Mrs. T.; wife; tired from doing nothing but the society drag; prolapsus and "adhesions"; in general, the + symptoms almost equalled the — ones; accommodation, 5.50, indicating 36 years, to which was added 6 years, 3 months, less 10 per cent for her mental disturbances over old school doctors' stories, or 5 years, 7 months, 15 days; making a total of 41 years, 7 months, 15 days. She was 41 years, 8 months, or 15 days to the good.

Case VII. Mrs. P.; trained nurse; anaemic and neurasthenic; history of endometritis for nineteen years; came from hospital where she had four weeks' rest after a curettement; had been operated on for "floating kidney" two years before; rheumatism in arms and feet; cold feet and hands; weighed 119½ lbs.; had worn + 1.50 for several years; error + 3.00 accommodation 8.00 D., equals 26 years, 8 months; adding 3 years, 4 months for the entire errors, and 7 years, 6 months more for mentality made a total of 37 years, 6 months. She was 38 years, 3 months, or nine months to the good, on account of her rest at the hospital, which was the reason no allowance was made for her symptoms, except in adding for the mentality. After twenty days further rest, on strict diet, she went to work, stronger than she had ever been, and weighing 137½ pounds.

Case VIII. Miss C., teacher; divergent squint; anaemic, neurasthenic, sore spot in back, couldn't wear corset, headaches, constipation, indigestion; measured 8.00 D., or 26 years, 8 months, and 1.50 hyperopia, for which was added 7 years, 6 months, making 34 years, 2 months. Deducting for her — symptoms, 25 per cent for the squint, 50 per cent for the anaemia and neurasthenia, 25 per cent for the sore back, and 50 per cent for the headache, indigestion, etc., aggregating one and one-half times the amount added for the error, or 11 years, 3 months, from 34 years, 2 months, left 22 years, 11 months, and when she said she was only 22 years even, I informed her if she recovered it would be a triumph for neurology, as she was below the dead-line. I fixed her back in

half a minute, straightened her eyes in two days, and when she showed amazing improvement in four days I let her go home where she would have absolute quiet. In three months she reported well, gained 21 pounds and was wearing a corset with comfort.

Measurement of nerve strain caused by the eyes is one thing, and proving of our work and casting up a final account for the data is another.

Taking one at a time, we first take the prescription as it comes from the trial frame, and if there is any plus in it, it will be in the sphere of at least one eye, and we base our calculation thereon. We know that in hyperopia there is accommodation and convergence and that the convergence must be neutralized by negative pull, thus if the eyes are equally defective, the amount of convergence and negative pull will aggregate an amount equal to the accommodation, therefore we know that adding the accommodation of the two eyes together and multiplying by two gives the strain per second. We know that if the two eyes are different, that one will be the fixing eye, and we proceed as if the error in the other was the same—this where there is a wide difference between the eyes; where the difference is only .50 or less, we add the spheres and multiply by two. If one eye was hyperopic 1.00 and the other eye myopic, we would proceed as if each were hyperopic 1.00. If one eye was myopic and the other simple hyperopic astigmatism of 1.00, we would figure as if it was hyperopia 1.00 in each eye. In all these cases we figure sixteen hours per day.

In figuring on a myope, we find his far point with naked eyes, make the calculation for three hours, for accommodation and convergence, then proceed to measure his error and deduct the amount of his myopia. Example: With the dynamic test we find the farthest point he can read instead of the nearest. Suppose it to be five inches, this would mean for an emmetrope: 8.00 D. accommodation in each eye, and 4.00 D. convergence in each, or 24.00 D. in all. Then we measure him, and find there is 3.00 D. Myopia in each eye. Taking 6 from 24 leaves

18×60×60×3=194,400 D., deducting normal 100,000, leaves 94,400 strain.

In figuring the strain of extra hours' work, we find the distance same as above, except, instead of the farthest point, we find the customary point, usually about 13 inches, which would be 9.00 D. per second for emmetropia or corrected hyperopia. If he is an emmetrope, the extra hours' work is all the strain he has, but if he is an uncorrected hyperope, we add the two amounts of strain together.

Remember that in putting glasses on hyperopes, we save the necessity for 4.00 D. per second with a pair of plus 1.00 D.; 8.00 D. with plus 2.00; 12.00 with plus 3.00; 16.00 with plus 4.00; but beyond that there is not so much, as patients rarely try to overcome 5.00 D. constantly. But the mere fact of putting on these lenses does not save all the strain until the patient relaxes accommodation enough to see normally with them. Next we take up the matter of the final calculation and proof of the work.

We first take the dynamic showing with correction on and refer to the large table in the neurometer, which tells us the age of an emmetrope with that much power shown in his gauge; second, we note the amount of hyperopia in the greatest meridian (or strength of sphere) and turn to the other table, which tells us how much the gauge is deceiving us by the first test; we add this to the first showing, and that tells us what that individual should show were he an average hyperope of the age specified. Next we add from five to ten years for mentality, if the person is doing work that requires thinking and reading, and he has an education, either erudite or actual; these additions are either 5, 6¼, 7½, 8¾, or 10 years, any one who does not merit the addition of five years needs nothing. Low, 5; low medium, 6¼; medium, 7½; high medium, 8¾; high, 10.

Whenever we can find extra hours' work we figure on them instead of using the above, because it is more accurate. After having footed all these figures, we show patient how old

he ought to be, then we undertake to tell him how old he is; not that we care to mystify anyone, but in order to see if we can establish the value of symptoms; so we make a new table beginning with the same figures as before, but, instead of adding the full amount of his error, we deduct, as specified elsewhere, and the deductions may be as little as 5 per cent. and as much as 50 per cent. for any one symptom, the former would be for minor symptoms, and the latter for major ones, such as a combination of dysmenorrhea with menstruation every two weeks and flooding. Then we would take into consideration that we should reduce our estimate for mentality almost in the same proportion on account of the conditions found. This will be found to run a little low, as a general thing, but it gives a better chance to say encouraging words to your patient if the age is a little more than your figure. Or as the patient's mentality is liable to be influenced by his condition, it is a little easier to take the amount to be added from one of the five figures compared with an ideal standard, and make no deductions at all.

Of course some complications arise when one has been wearing a correction or part of it, but when the total strain is figured first, we can then judge, in making the second calculation, by what we have allowed for the symptoms present in other cases with that amount of strain, whether under the same circumstances or not. This proves the value of having a system. We have an ideal eye, stomach, liver, etc., and even the ideal person; more than that, we have the actual defective person and organs, so that we may master the principles of our own system by practicing according to natural laws.

A MUCH MOOTED QUESTION.

How to Treat Cross-Eyes and Alleged Muscular Insufficiencies.

It is more than passing strange how the medical profession accepts assertions from self-constituted authorities without putting them to tests. Long ago some writer declared that cross-eyes are caused by paralysis of one of the sixth cranial nerves which operate the external recti, and it has been taken as indisputable, when if the author of the assertion, or those who read after him had possessed a modicum of knowledge of the mechanics of anatomy and of the possible causes of derangements they could have proved in one minute, or less, that the assertion had no foundation in fact. The test is a simple one: cover the fixing eye and direct the patient to fix with the other, without turning his head. If he does it, and I have never found one who could not, unless the eye was blind, it is positive proof that the nerve is not paralyzed. Then it ought to occur to a thinking doctor that it would be a queer state of affairs if one of a pair of nerves should be paralyzed and no others suffer the slightest. It is not impossible, but is highly improbable.

Again, it is a common fault among doctors to be satisfied with one theory of cause and not look for others. They wait for the leaders to make discoveries while they maintain the code of ethics' "air of peculiar reserve" toward the laity and talk about the progress "we" are making. I have never seen a case of convergent cross-eyes that was not produced by one of two causes, ametropia or operation. It is true many cases appear after the spasms of whooping cough or irritation or exhaustion from other disorders, but the primary cause was defect in the physical proportions of the eyes. This has been proved hundreds of times by myself and my pupils by correcting the defects, or overcorrecting them for a time, when the eyes straightened without further assistance. It is very rarely that operation is needed and when we are a little wiser I am sure it will never be done.

In cases of cross-eyes, from other cause than operation, both eyes deviate, but the necessity for vision impels the fixing of one eye by the controlling center, (one of the most perfect illustrations of Nature's power of adapting herself to circumstances), while the other is permitted to do all the turning. Sometimes the eyes alternate in fixing and as such are the easiest to straighten by our method, we have learned that it is a good idea, in other cases, to first create this tendency by covering the fixing eye and compelling the other to fix. In little children we are often able to straighten the eyes without glasses by using such tactics and strengthening the general nerve supply by a positive diet. Of course, if that fails we know it is because we did not remove the cause, and we resort to glasses. The only reason we do not put glasses on in the beginning is that while we know the error of refraction is there, we know that if a system is in perfect order, in every other particular, the excess nerve demands of the eyes can be supplied without danger to health, at least for several years, and it is to let the little one go without the inconvenience of glasses if possible. Of course, if there are complications, such as headache, constipation, fits, etc., we use every precaution to insure winning from the beginning. Then, occasionally, when the child has grown strong, we try laying aside the glasses always remembering and informing the guardians that in so doing there is some risk of the eyes crossing again; but if they do, we can do the work over.

The manner in which hyperopia causes convergent strabismus will be understood best by first comprehending the normal relation between convergence and accommodation.

Fig. 56 shows the two eyes fixed on a point, A, say 13 inches distant, the axes of the two eyes each turning in to the median line, and the accommodation working so that A and B B are in conjugate focus. The latter, being two independent duties, each requires 3.00 D. effort from the nervous system, while the former, being a joint duty, only requires a total of 3.00 D., or 1.50 each, delivered through the internal recti

muscles from branches of the third nerves that operate the accommodation. All is under direction of the controlling center, C, back in the brain; it, in turn, receiving its impulses from the nerves of sensation, the second or optic nerves. As

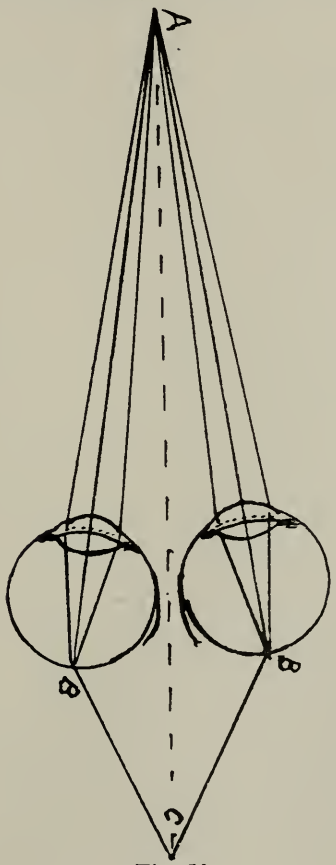


Fig. 56

this is the natural situation, and as such functions belong practically to the sympathetic or involuntary system, let us express it as follows:

An emmetrope working at 13 inches requires from the nervous system: For accommodation, L.. 3.00 D., R. 3.00 D.; for convergence, L. 1.50 D., R., 1.50. D.; total, 9.00 D.

In order to put this in still more comprehensive form, let one second be the unit of time in our calculations. Thus, if it requires 9 D. for one second at the 13 inch point it will require 60 times 9 D. per minute or 540 D., and 60 times that per hour, or 3,240 D.; the average number of minutes close work daily is only about three hours, so that the total demands of these two functions is only 97,200 D. daily.

Now take a hyperope of a 3 D., who must use his accommodation unnaturally on account of the defect in the form of the eye-balls, but who has exactly the same anatomical relations between accommodation and convergence. He cannot accommodate without converging and while the accommodation only brings his retina in conjugate focus with objects at infinite distances, his convergence brings the axes to a point 13 inches away. The only things left for the controlling center to do are, either fix with one eye and let the other turn in toward a point 6½ inches from the face, or send enough energy to the external recti, over the sixth nerves, to hold the axes parallel in spite of the convergent pull. Thus, there is a twofold strain on the hyperope: First, his demand is all in excess of normal; second, it forces nerves which, ordinarily, work alternately, to work at the same time. It follows, naturally, that when the nerve supply under control of C becomes weakened, the first place the innervation is withdrawn will be from the sixth nerves, thus after an attack of acute disturbance, such as typhoid, scarlet fever, diphtheria, or weakening from other cause, the eyes are liable to cross. Or, if there be spasms, such as from whooping cough, the irritation would give the third nerves an advantage over the sixth and the eyes may turn.

The nerve demand in a hyperopia of a 3.00 D. would be as follows: For accommodation, L. 3.00, R. 3.00; for automatic convergence, L. 1.50, R. 1.50; for negative pull, via 6th nerves, to prevent convergence, R. 1.50, L. 1.50; total, 12.00 D.

Therefore, 12 D. for one second means 720 D. for one minute, 43,200 D. per hour, and 691,200 D. per day of 16 hours, which is the average time people are awake daily. Then if this person is required to do the average number of hours close work daily his total demand is 788,400 D. daily against the normal demand of only 97,200 D. Is it any wonder he becomes cross-eyed? Is it not remarkable that there are not more cross-eyed ones? Is the assertion that eye strain is one of the chief causes of human ills a claim to be ridiculed or disputed? It is only done nowadays by utter ignoramuses.

The philosophy of my treatment of convergent squint should be clear now: Simply correct the error that requires the accommodation, thus doing away with the convergence, which in turn makes the divergent pull unnecessary. This is the proof that every + sphere, worn constantly for the correction of hyperopia, saves twice as many nerve units per second as the lens has units of power. But it is not so simple a proposition when it comes to the solving practically. The operator must not only know the anatomy and physiology of the eyes particularly and of the system generally, the sympathetic relationship between organic functions, etc., but he must know physics and mechanics and have a natural tact and adeptness, not possessed by everyone, to measure the errors correctly. The assertion by some would-be oracles that none but physicians are competent to fit glasses to the eyes is foolish in view of the fact that very few physicians ever used a set of trial lenses or received any instruction whatever about eyes, except possibly something about pathology of the eyes, and that was false. Ask the first ten physicians you meet; be practical. The assertion is on a par with another, by the same wiseacres, that no one can get an eye correction without first using a cyclopegic. They are the same individuals who declare that

the old schools of medicine have patent rights on all discovered or undiscovered methods of relieving human ills, and expose themselves to ridicule and fear for their sanity by saying: "It is better that a patient die in the hands of a regular physician than recover under the ministrations of an empiric." It is the favor new schools are meeting in the estimation of an intelligent public that drives them frantic.

An ophthalmologist, treating convergent squint, begins by disregarding vision to the extent of prescribing, for temporary wear, such + glasses as will blur the vision of the fixing eye for distant objects until it is worse than the other, provided, always that the other has enough to enable the patient to see sufficiently to take care of himself. Often, on returning in a few days, vision will have improved very much; then we blur some more, until the spasms in the ciliary nerves and those of the interni have relaxed and the eyes are straight, when, if vision is not perfect, we give the correction that will make it as nearly so as is possible. Sometimes the blurring process is not successful because the temperament of the patient is such that he adapts himself too readily to any situation. In such instances we reduce the blur for a few days to excite the desire to see, and thus set up influences for reaction. If one eye is totally blind it makes little difference in the proceeding; we blur the good eye to about 20/50 or 20/60, stop all close work and get the system in good condition by diet, rest, etc., as we should do in all cases, when the blind eye will straighten, affording the best possible proof our philosophy is correct. If one eye turns up or down, treat in the same manner.

If the deviation is outward it is from deficiency to the point of exhaustion at the time it occurred, or from blindness in one eye which disconnected it from the controlling center. Theoretically the practice suggested for convergence should not work, but by modifying it a little we are often able to get fine results, provided the deviating eye can see. If the patient's nerve supply measures below normal we blur the good eye and barely correct the other, to force it into action,

then tone up the system with dietary, rest, etc. In all cases no harm is done by having the patient turn the deviating eye to the opposite side as far as possible, the lids being closed, then the operator holds it by gentle, firm pressure, while patient tries to turn it back; teach the patient to do it himself at frequent intervals.

The length of time required to complete the work of getting cross-eyes to work together, straight, varies, from a few seconds to several months. Something depends on the mentality of the patient and something on the physical temperament, just as in all other things. The operating fiend objects that it takes too long. We reply that operations made unnecessarily are a crime, hence nearly if not quite all cross-eye operations are crimes. He says, "But your patients have to wear glasses." We reply, "So do yours; if they do not they soon require another operation, and another until the eyes are finally worthless." Almost half of the total number of divergent squint cases I have met testified their eyes formerly turned in but were operated, then turned out, and they were afraid to let the alleged surgeon do any more cutting. There is also more or less danger of blood-poisoning after operations.

But cutting muscles for cross-eyes is a mild crime compared with the slashing oculists do for that myth "muscular imbalance." I have made an assertion and the proof is due. First, let me make others and I will then proceed to prove all at once: They all apply what they call muscle tests. The first one comprises the Maddox rod, or double prism on one eye and a colored glass on the other. We prefer to use the double prism because it is simpler than the Maddox rod. Let the colored glass be on the right eye for this illustration. When adjusted properly and looking with both eyes the patient should see the colored light in line with and midway between the other two, all in a vertical position, and when he does it is called orthophoria or a normal state; but if the red light is seen to the right they say the right eye is turning in from a weakness of the

external rectus muscle, and as esophoria means a tendency inward they apply that word to the condition and declare they must cut the internal—because the external is weak! If the red light appears to the left it means to them that the internal rectus of that eye is weak—and they cut the external! They call this exophoria, because they think the right eye turns out. If the red light appears above the mid-point they call it left hyperphoria, if below that point, right hyperphoria—one of them calls it left "cataphoria," but as catoptrics is the science of reflections we pass him. They apply the term heterophoria to all deviations. To recapitulate briefly, they say that in all imbalances the fault is in the muscles, that it is always weakness of the muscle on the opposite side of the eye from the way it turns and that the eye turns opposite to the way the light deviates. I say, both eyes turn, which is easily proved, theoretically, by the anatomical and physiological relationship existing between them, and practically by reversing the prisms and colored glass, the latter being on the left eye will show as much deviation as was shown by the first. I am almost afraid to tell them this lest they cut the muscles of that eye too. And, lest someone be misled by a difference in the amount of deviation when the test is made, let it be remembered that repeated tests with the first arrangement will often show different amounts of prism required to get the lights in line, just as the patient grows more passive or more irritated by the test. I say, further, that in the so-called heterophoria the eyes deviate the same way the lights appear to, hence what they call esophoria is really exophoria and what they call exophoria is really esophoria, while what they call right hyperphoria, that is, right tending upward, is really a downward tending, and when they say it turns downward it is really tending upward. Also what they call hyperphoria is often a vertical squint or hypertropia, as they would call it, to class it with cross-eyes. Finally, I say what they call muscular imbalance is not muscle trouble at all, but is due solely to irritation or weakness of the nerve supply in the cerebellum. All

of which, if true, proves their operations to be crimes, committed through ignorance or willfully. The reason I added the word "willfully" is because, if they find the eyes in perfect balance by the test described they have another called the duction test, which they apply, after having fixed an arbitrary standard of power each set of coordinate muscles should exhibit and if one set shows more power than the standard they cut it; if it shows less, they cut its antagonist. They put on strong prisms, apices over the muscles to be tested and

The interni must overcome not more than 24° or less than 20°.

The externi must overcome not more than 8° or less than 6°.

The superior must overcome not more than 4° or less than 3°.

The inferior must overcome not more than 4° or less than 3°.

Thus they discover what they call "latent" muscle troubles. One of my students, aged 60, exhibited by this test, 8° with the interni, 3° with the externi, and 1° with the superior and inferior, so I wrote one of the partisans of the test to find which muscles to cut, inasmuch as by his theory they all should catch it, but I never received a reply. I did not expect one.

Now for the proofs: None will deny that motor nerves are the sole source of power to move muscles voluntarily. All will admit a certain elasticity of the fibrous structure, but it is always negative in straight muscles. Hence muscles are only the mediums through which nerve force is applied, just as engines are only the mediums through which steam and electricity are applied. Then, if we have a case of spasm of accommodation it is irritation of the nervous system at being called on to work overtime, and it is but natural that other branches of the same nerves would feel the extra current, particularly those operating the coordinate function with accom-

modation, namely, the convergence, and, when the double prism and colored glass test is applied we would expect the eyes to deviate inward as soon as control was taken from C, (Fig. 56), and if the eyes carry the lights in the same direction they turn, the red light, on the right eye, should appear to the left of the others, while the others should appear to the right of the red; in other words the lights should cross over because the axes do. Now let us see if they do.

First take a vigorous person with no presbyopic tendency and put the double prism on the left eye, the other being covered, and have him look at a small spot, say as large as a pin head, on a piece of white paper at about six inches from his face, and adjust the prism so he sees two spots in a vertical position. Note how the eyes are converging, then uncover the right eye, when he will tell you the middle spot is decidedly to the left. Then take a person with a presbyopic tendency, but who can still accommodate some, and try the same test, when his right eye will fail to bring the middle spot even with the others. Then draw a line through the spot and repeat the test on both, when, unless the first one has a tonic spasm, or cramp, he will see all the spots on the line, and, the second will do the same, unless his presbyopic tendency is very strong. This experiment proves two things: First, that the object deviates the same way the eyes turn; second, that the dot-and-line test as they use it, to find "heterophoria at the near point," is worse than worthless.

Fig. 57 shows an esophoria, or inward tending of the eyes, under the test. I have drawn the deviation all in one eye in order to make the illustration simpler. The left eye, with the double prism, sees two lights at twenty feet, one above and the other below the axis at the macula because the prisms are of equal strength; and its axis is in direct line with the real light, because we permit the patient to fix before uncovering the other eye. The other, when uncovered, gives way to the positive or negative impulse present because the two eyes are thrown out of gear and the controlling center, not being able

to focus its image with the other two, simply lets it drift with general conditions. In this case it is a positive impulse, also

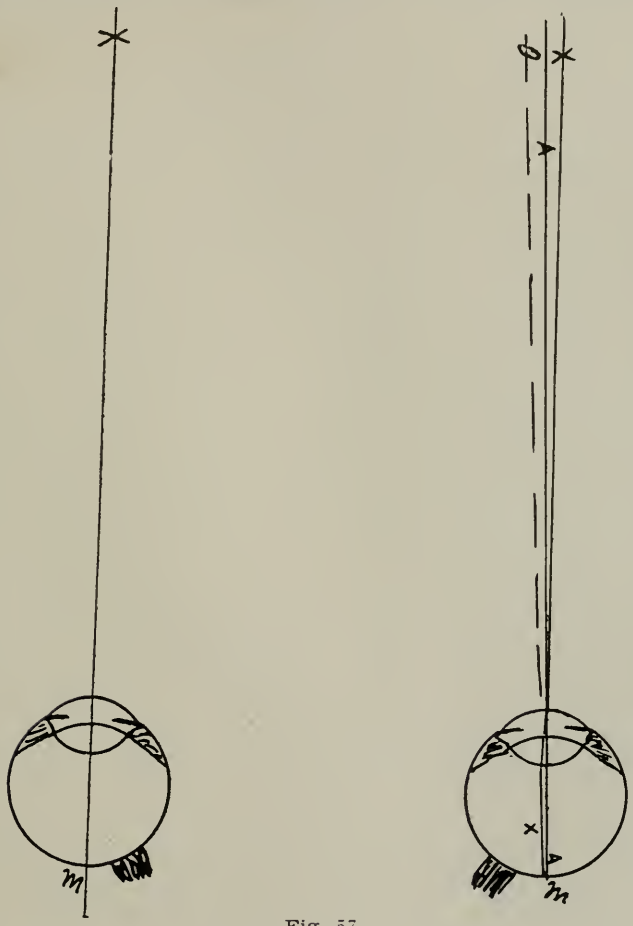


Fig. 57

exhibited by spasm of accommodation and of sphincter nerves throughout the body, so the axis A turns in from the normal line X which is the exact direction of the object. The turn is so slight, however, that the ray, X, crosses the axis, A, before reaching the lens, and is broken back toward the axis so that it strikes the macula as nearly the center as either of the images in the other eye can be, and, as the direction from the lens to M is as if the ray came from O, the light appears to be at O. If from weakness of the supply to the third nerve branches the eyes deviate apart when thrown out of gear, the lines O and A would be on the other side of the line X. The prism, apex toward the position where the center light should be, which puts the deviating lights in line, does not, as they think, measure the amount of the deviation in degrees. It merely indicates the relative intensity of the spasm or the extent of the weakness in the nervous system, as is proved readily by measuring the distance of the deviation in inches and observing that while it may remain the same at different tests the amount of prism required to supply the impulse to put the lights in line is variable. Also, one person, with a deviation of twelve inches, may require a 12° prism while another with greater deviation may need less. The best way to take these measures is to have a strip of white paper several feet long on the wall, with the light hanging exactly in the middle, and through the middle of the paper have a plain, black line, half an inch wide, with vertical lines drawn through it every few inches. This will appear in duplicate through the double prism; then have the patient tell where the red light is with reference to these lines.

The ophthalmologist uses this test, not as a muscle or eye test, but as a static test of the state of the general nerve supply. He would no more think of prescribing prisms for such deviations than he would think of cutting muscles, and he would no more cut muscles than he would cut throats. We never supplant nature, and we never try to assist her unless we know exactly why we do what we do. When this test is off, the eyes

are in gear and the controlling center supplies all the impulse necessary.

Then there is another "phoria," called cyclophoria, in which the eyes turn on their optical axes and present oblique astigmatism when the principal meridians should be vertical and horizontal. If there is a spasm of the nervous system it may exhibit in the inferior oblique muscles and pull the eyes inward below, rolling the tops outward, or, if there is nerve exhaustion, the inferior oblique will be enervated, letting the superior oblique pull in at the top, from its elasticity, when there is less resistance than usual, rolling the lower parts outward. The reason in both cases is that the inferior oblique is operated by the same nerves that supply the accommodation and the internal recti, hence the tension, or lack of it, on all muscles operated by the same nerves. A test for cyclophoria, which is not reliable, however, is to put the double-prism on one eye and adjust it so that a patient looking at a horizontal line, about half an inch wide and fifteen or twenty feet away, will see two; then uncover the other eye when he should see a third, midway between and parallel with the two seen by the first eye. If the nasal ends tilt downward, the principal meridians nearest horizontal are tilting upward, indicating a spasm of the nervous system, exhibited through the inferior oblique muscles; if the nasal ends tilt upward it indicates the principal meridians are tilting downward from nervous weakness, exhibited through the inferior oblique muscles. This is just opposite to the indications by the test with cylinders, when there is astigmatism, because then we have the positions of the principal meridians indicated by the axes of the cylinders. The reason the prisms and line test is worthless is the same that makes the dot-and-line test a nullity, viz.: the lines offer the controlling center a guide and it often takes the hint disclosing no disturbance because the parallelism of the lines is maintained. In all cases where there is doubt about the location of the axes, prescribe + spheres. It is proper to say that when astigmatism is great enough to impair vision seriously it rarely creates nervous effort enough to upset the system.

The treatment indicated by + impulses is stop the cause of spasm by correcting the hyperopia and the symptoms dynamic and static will soon disappear. If there are — impulses they mean rest in addition to the correction. In connection

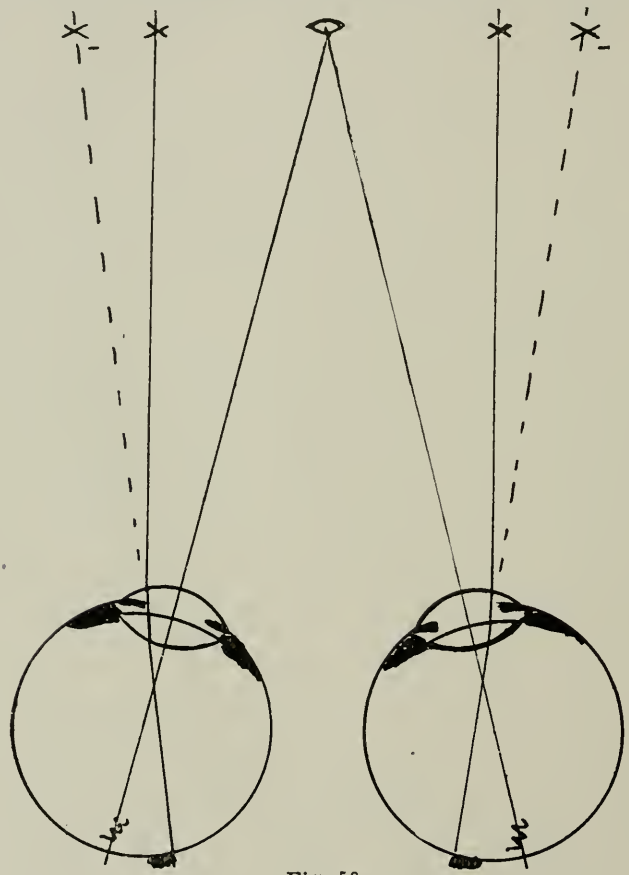


Fig. 58

with both we find, often, other causes of disturbance and we remove all of them without operation, except a few hopeless cases who must be content to take the chances of operation, which, if successful, can only keep alive what is left; they are never whole afterward. We send them to those who boast they would rather operate than eat—we prefer to eat and think we are greater surgeons when we can save a person whole than those who take chances wholly unnecessary and refuse to investigate our methods, but, nevertheless, condemn them even to libeling us.

"But," you say, "how did your opponents get the idea that in heterophoria the eyes deviate opposite to the way the lights do?" All right, I'll answer that, too.

Fig. 58 shows two eyes fixing on a point six, or eight, or more inches away, and X X represent rays coming from a light fifteen or more feet distant. While only one image of O will be conveyed to the brain, there will be two of the distant object; they will be imperfect, that is, not clear, because the eyes are in conjugate focus with the nearer point and because the retinal impressions are not made on a highly sensitive part—some of the image falling on the blind spot—and as refraction by both cornea and lens is in the outer hemisphere the lights appear in the directions X^1 X^1 on the dash lines. This is because the convergence of the two eyes is beyond the limit angle. The reader may try this and will find it true that when the eyes' axes turn so much with reference to a line toward a distant object, the object will exhibit the opposite deviation.

Fig. 59 shows a left eye fixing and the right eye doing the turning perceptibly, so that a ray from the object O appears as if located at O^2. If the eye turned out the lines Ax and O^2 would be reversed. When we are working with cross-eyes and the patient complains of seeing double we know we are getting along with the case nicely and as soon as the controlling center gets a hold the eyes will straighten and remain straight. Usually the deviating eye turns enough to let the image fall on its blind spot so it does not send any image to the brain, which relieves mental worry.

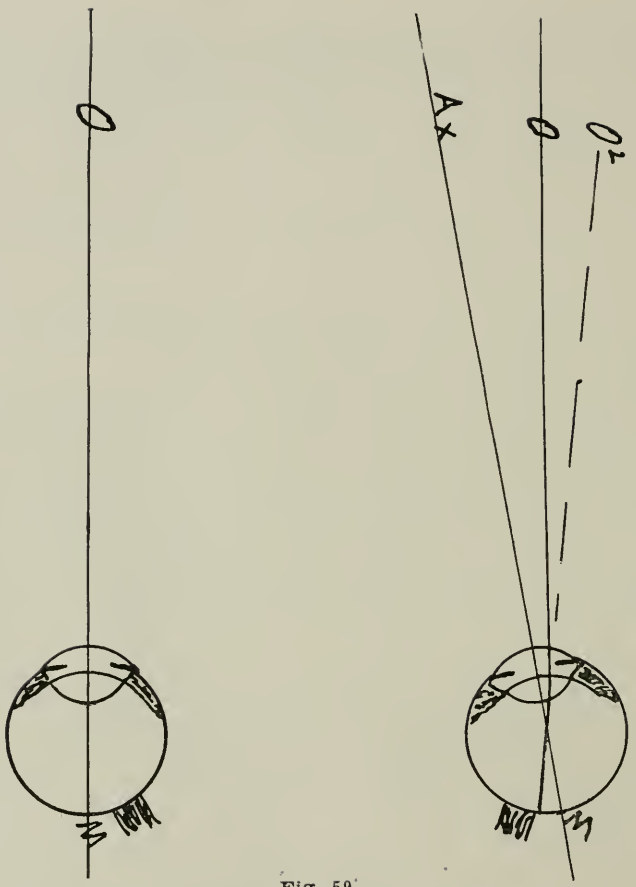


Fig. 59

Fig. 60 shows another situation which the reader may try. Fix the eyes on the distant object so that the axes are parallel, as are X X in the cut, then hold a pencil, or the finger,

a few inches away, when there will appear to be two, the right eye seeing the one on the left and the left eye seeing the one on the right, as shown by the dash lines. This is because the visual axes are beyond the limit angle for rays from the near

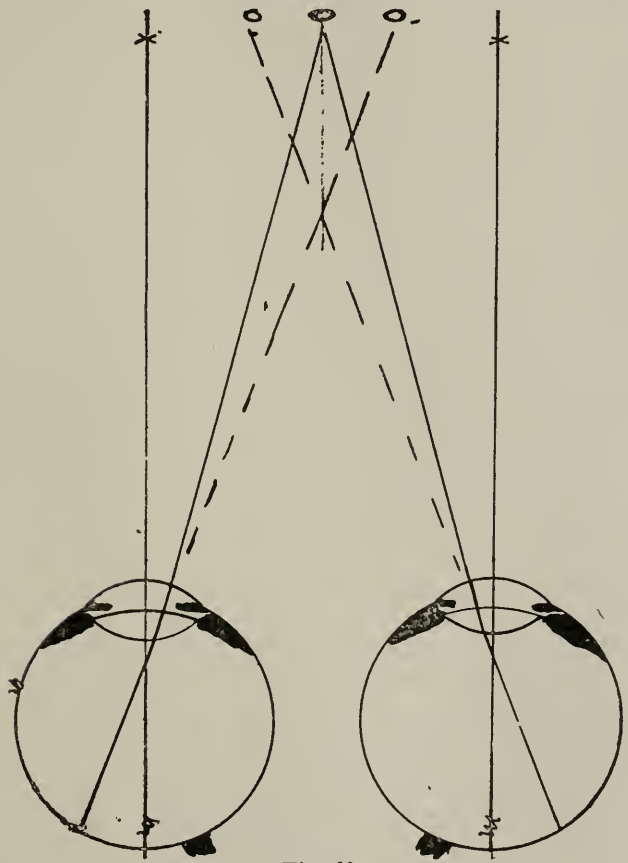


Fig. 60

point. This shows how, if the eyes turn out, a distant object would be seen as two, deviating opposite to the direction the eyes turn, except when they turn so far one does not participate in vision at all.

My answer then, is: My critics think because the lights deviate opposite to the turn of the eyes in strasbismus it must be true in all cases, whether the eye turns perceptibly or not, which proposition is false as I have proved, anatomically, physiologically, physically and clinically here, while several hundreds pupils and myself have proved it in practice so long that it seems almost absurd to give it so much space at this time.

So long as the deviation of the eyes does not disfigure the appearance there is no squint and when there is squint there is no need for a muscle test to tell which way the deviation is. When there is no deviation except as exhibited by the test the eyes always deviate in the same direction the lights do. I think that is stated plainly enough, and proved by the figures.

Vertical deviations show squint and exhibit diplopia with less amount of turn than in any other direction because the superior and inferior recti are operated by the same nerve branches and thus reach their limit angles quicker as is illustrated by the duction test.

SOME PRISM FIGURES

Which Prove the Fallacy of Claims for Them as Therapeutic Agents.

As refracting mediums and therapeutic agents prisms offer two distinct propositions. The first has been treated in the chapter on physics and the other is due to receive attention.

Take an emmetrope, or an ametrope, in good condition, so that the static test shows the three lights in line, and watch his eyes as you drop in front of them a 10-degree prism, base out. You will see them turn in perceptibly. The one on which the prism is placed will turn in at once while the other will turn out first, then in, as soon as it finds the first stop. This is because the first impulse to the other eye was transmitted by way of the optic commissure and the second by the controlling center when it discovered the situation. Now make a long horizontal line on the wall, in the middle of it hang a light; on either side of the light draw short vertical lines about two inches apart, making them plain enough to be seen readily; then, with the two lights seen through the double prism and the red one seen by the other eye, all in line, suddenly impose a 4-degree prism base out in front of the red glass and have the patient state the amount of the deviation caused by locating the position of the red light with reference to the short vertical lines, which will of course appear as two sets through the double prism (have patient ignore all seen with the red eye, excepting the light). Remove the trial frame and take two strings, each long enough to reach from the patient to the wall; have him hold two ends, one under each pupil, while the operator takes the other two ends and holds them taut at the points where the light is and where the displacement located it, the string from what was the red eye running to the displaced position and the other to the real position. These represent the true visual axes of the two eyes under the test and the distance from the face to the point where they cross shows the exact

angle of convergence caused by the prism. It will be found to be approximately one meter in tests of normal eyes, hence we know that a 4-degree prism base out causes practically one meter-angle of convergence, requiring .50 D. effort in each eye. Inasmuch as when such effort is caused in a natural way by a demand for accommodation, and as putting prisms on emmetropic eyes (or on fully corrected ametropic eyes), causes dimness of distant vision, we know the impulse to converge, even when caused artificially, brings with it the proportionate amount of accommodation, we have the figures for the nerve strain which would be caused by such prism as follows:

Convergence, L. 50, R. 50; automatic accommodation, L. 1.00, R. 1.00; total, 3 D. per second. $3\times60\times60\times16=172,800$ D. per day of sixteen hours.

In a hyperope of 1.00 D. the same prisms could be used to advantage because they would save one-fourth of the abnormal demands, thus:

Accommodation L 1.00, R 1.00; auto convergence L .50, R .50; negative pull by external recti to prevent convergence, L .50, R .50; total 4. D. per second. $4\times60\times60\times16=230,400$ D. per day of sixteen hours.

The prisms, making the convergence a necessity while the accommodation adapts the focus, the negative pull is not needed, and, as it constitutes one-fourth of the total the prisms save 57,600 D. daily. But would not a doctor be a chump to save that when he could, with a simple pair of + spheres, save the whole 230,400?

Here is another notable thing: If the prisms be prescribed in combination with the sphere the effect would be just the same as with the prisms alone, for, the prisms alone save 57,600 out of the 230,400, leaving the net strain 172,800, while in the combination the lenses would make the eyes emmetropic and we have shown that the strain on an emmetrope is 172,800.

Here is another: A pair of + .75 lenses each ground in combination with 2° base out, would be exactly neutralized therapeutically, except the psychic effect.

Accommodation, L. .75. R. .75; auto convergence, L. .37½, R. .37½; negative pull via sixth nerves, L. .37½, R. .37½. Total, 3. D. per sec. 3×60×60×16=172,800 D. daily.

The correction makes patient emmetropic and saves the above amount, but then the prisms come in and cause:

Convergence, L .50; R .50; automatic accommodation, L 1.00, R 1.00. Total, 3. D. per sec. 3×60×60×16=172,800 D. daily.

Then take a hyperope of 1.00 D. and correct the error, but combine 4° prism, base out, with each lens, and the effect would be: The spheres make an emmetrope and save 230,400 D. daily, but the prisms cause two meter-angles convergence and total nerve strain, thus:

Convergence, L 1.00, R 1.00; automatic accommodation, L 2.00, R 2.00. Total 6. D. per sec. 6×60×60×16=345,600 D. daily, or exactly the equivalent of the strain caused by 1.50 hyperopia. The same result could have been obtained with a pair of — .50 spheres.

Take a hyperope of 3.00 with a total strain of 691,200 D. daily and give him + 2.00 ⌒ 2° base out, each eye, and the lenses will save 460,800, while the prisms save one-fourth of the rest or 57,600, a grand total of 518,400 out of a possible 691,200; but if + 1.00 had been added to the lens instead of the prism, the whole would have been saved.

Take the same case and combine with the + 2.00 lenses 4° prism each and the effect will be that the lenses, leaving 1.00 D. hyperopia uncorrected, would mean nerve strain:

For accommodation, L. 1.00, R. 1.00; auto-convergence, L. .50, R. .50; negative pull, L. .50, R. .50. Total 4. D. per second. But when the prisms get in their work the result is different. They cause a strain as follows:

For convergence, L. 1.00, R. 1.00; auto-accommodation, L. 2.00, R. 2.00. Total, 6. D. per second. There would be some benefit even from this combination because the original strain, from the error, was 12 D. per second and half of it would be saved; but if the prisms were left out two-thirds would be saved.

The whole matter resolves itself into this: If 4° base out causes 172,800 D. daily strain on an emmetrope, whether naturally so or made that way artificially, 1° would cause 43,200 D. daily up to the limit of capacity to overcome prism degrees, and to find the damage any amount of prism base out will do, multiply the above figure by the strength of prism. The reason prisms do not always do harm is because the doctor unwittingly leaves part of the hyperopia uncorrected or the benefit from the spheres is so much greater than the damage done by the prisms that the net result is good. But neither the prisms nor the doctor deserves any credit.

We are not yet able to measure the exact strain when the prism is base in, but it is a reasonable estimate to put it at about one-fifth as much as if base out, because it bears on the sixth nerves, which have no branches, while the third have five principal ones, therefore each degree, base in, would cause 8,640 D. daily strain, up to the limit of capacity to overcome them. Base up or down, would bear on third nerves again and we estimate the strain at one-third as much as if base out, or 14,400 for each 1°.

The capacity of the interni rarely exceeds 20°; that of the externi 6°; that of the superior and inferior recti 3°.

To test the pulling powers of prisms within the limit, and the non-pulling powers of those which exceed the limit, take a 2°, hold it base down in front of one eye, both being open, and look at a light several feet distant, when it will appear as two; fix on it until it appears single, then withdraw the prism. If it does not pull when put on it will as it leaves. Then try a 10° in the same manner and there will be no pull because the job is such a big one there is no effort to do it.

Possibly some eye doctors who have been prescribing prisms with varying results will now be able to see why they won when they won and why they failed when they failed, which was frequently.

"But," someone says, "What are you going to do about the muscles when tests indicate prisms are needed?" I deny

there are any such cases, with the possible exception of a lack of ability in some old people to converge or in a myope who tires at close work or without correction, when prisms, bases in, might be used for reading only, in connection with the additional spheres required in the case of the presbyope and without lenses for the myope; I never saw but one person who required them even for that purpose. In case of such need, however, here are the figures:

For 1 meter-angle 4° base in, part in each eye.
For 2 meter-angle 8° base in, part in each eye.
For 3 meter-angle 12° base in, part in each eye.
For 4 meter-angle 16° base in, part in each eye.
For 5 meter-angle 20° base in, part in each eye.
One meter-angle is 40 inches.
Two meter-angle is 20 inches.
Three meter-angle is 13 inches.
Four meter-angle is 10 inches.
Five meter-angle is 8 inches.

EYE INSTRUMENTS AND MACHINES.

Saving the Ophthalmoscope the Remainder Are Valuable Only to Bluffers.

The ophthalmoscope is easily the most important objective instrument used in examinations of cases, but few realize the fact as is proved by the manner in which they use it. The indirect method of observation consists of throwing light into the eye from a point ten or twelve inches away and interposing a strong + sphere; this may be imposing in appearance but it is mostly humbug on the part of the operator because he can not hold all the points necessary to be in line to see anything of the retina and when he is able to do it he only gets an inverted aerial image. If one insists upon that method he should get one of my instruments, Fig. 61, because it keeps all points in line and gives the best results possible indirectly. It is comparatively inexpensive, is portable, weighs only seven pounds and is lighted directly instead of by mirrors.

The best method is the direct one, because the operator sees the retina instead of its picture, and sees it upright instead of reversed, besides the facilities it affords for exploring parts not possible by the indirect method. The Loring, nineteen-lens instrument, Fig. 62, is the best because it is simplest. It comprises in one disk fifteen lenses, from 1. D. to 7 D. + and from 1. D. to 8. D. —; then a second disk carries four lenses +50. and + 16 D. and — .50 and — 16. D. If more than the highest number in the lower disk is wanted turn on the 16. D., + or —, then rotate the under disk until the desired number shows. A + 16. on + 7. would register + 23. of course, but by rotating the lower disk the + 7. is displaced and — 8. is combined with the + 16. giving + 8., then further rotation brings it on up to + 16. and still more turning add + 1., 2., 3., etc., up to 23. D. again. The — works in the same manner, up to 24. D.

Books on the use of the ophthalmoscope are misleading in

two important directions: First, many of them convey the idea, either directly or indirectly, that the authors measure errors of refraction with it, which is an impossibility, because not only the patient but the operator would have to be atropized so thoroughly that neither could work the accommodation, and were that possible, the skill required to get the same focus on the vertical and horizontal vessels, the vertical

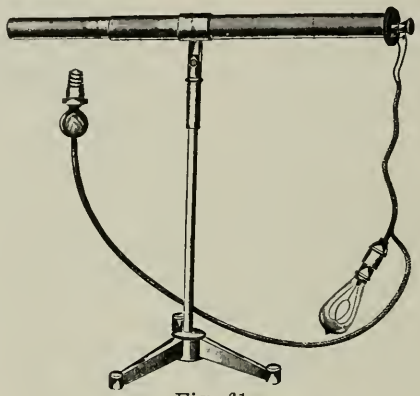


Fig. 61

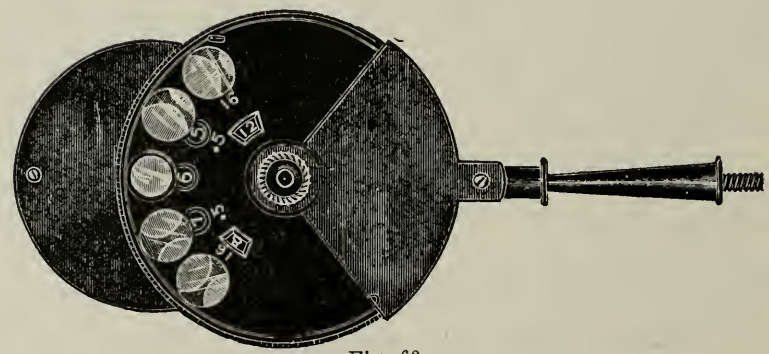


Fig. 62

being much larger, would be impossible of attainment; hence such claims are either foolish or deliberate lies. Second, they illustrate diseases and alleged diseases and the student abandons the instrument because he finds nothing to correspond with the pictures. The real value of the ophthalmoscope lies in the facility it affords for the study of the quality and quantity of the blood in every case. It is of little value to the oculist because he is strictly an eye doctor, and has no idea of the relation of the eyes to general ills. When the general practitioner learns what he should there will be nothing left for the oculist or optician, while the ophthalmologist will always be in demand because of his drugless creed and general utility.

The things to learn about ophthalmoscopic practice are: First, how to place the patient; second, how to get the best view of the fundus; third, what are the variety of appearances of the normal retina; fourth, how to differentiate between physiological freaks and true pathological conditions; fifth, the relation between exhibits and causes; sixth, what to do for them.

The patient should be seated comfortably and look straight ahead. The optic disk is always the chief objective point and as it is located about fifteen degrees from the posterior pole, on the nasal side, the operator must throw light into the pupil from a point about the same distance on the temporal side; the light, if a mirror without electric attachment is used, should be about two feet behind the patient and far enough on the side so that it will shine past the edge of the orbit to the mirror, leaving the eye in the shadow. If the luminous instrument is used it is easier to get light into the eye, but, on account of an awkward crook in the handle to make room for the small electric globe, it is not so convenient in making wide explorations. The light, the patient and the operator must be on the same plane, which may be either horizontal or oblique; if oblique, and the operator is shorter than the patient, the light must be higher; if he is taller than the patient,

the light must be lower; if on a level, the light must correspond. If the first attempt fails to give a good view, try again. A good guide is to imagine the patient has two eyes in the back of his head, and if looking into the right, aim so the light would pass through the middle head and out through the imaginary right eye on the opposite side of the head. If the blood-vessels are seen, but not clearly, twist the handle of the instrument a trifle so as to change the direction of the light; if the disk and vessels are seen, but dimly, turn on — spheres to offset the operator's accommodation. Unless the operator has much astigmatism it is best to work without glasses because the need can be supplied from the battery of lenses in the instrument. Learn to use either eye, allowing the other to remain open. Do not twist the neck; sit erect, except that it is necessary to lean forward slightly. The back of the operator's chair should be even with the front of that occupied by the patient. A piano stool or other adjustable chair is convenient.

Fig. 63 shows an average normal retina, except that the veins, the darkest lines, are a little too dark; there should be a faint light streak in them, as shown in the arteries, represented by the lighter lines, which are a trifle too light. The white spot in the center is the optic disk, or blind spot, where the retinal arteries and nerves enter and the veins leave the globe; the solid field shows the capillary system, which, combined with the nerve branches by delicate connective tissue, constitute the retina which extends from the edge of the disk forward to the edge of the ciliary body. The vessels should be of regular sizes, gradually smaller toward the periphery as they divide into branches. The currents of the arteries are from the disk and those of the veins toward it. Examination of a dozen or two pairs of eyes of healthy persons will give the student a better idea of what the average condition is than a whole volume of pictures could do. He will discover that in healthy children the contents of the arteries and veins is so nearly the same color that it would be difficult to distinguish them were it not

for the extra size of the veins; while in youth and middle age the difference is marked, and in old people quite decidedly so, partly because of diminution in the arterial supply and partly because of lack of tension in the walls of vessels which permits them to flatten under the pressure of the vitreous humor against them. In brunettes the blood is usually darker than in

Fig. 63

blondes. There may be deposits of pigment partly or all around the edge of the disk; or there may be great patches of pigment or even a deposit as white and shiny as the sclerotic, without inflammation, interference with the vascular system, or diminution of vision. The number of visible vessels varies from six to as high as thirteen. The vessels may not come so near to each other in the center of the disk as shown in Fig. 63 and some may disappear at the edge of the disk as shown in Fig. 64. These appearances are caused by a cupping of the disk and have no particular significance. Fig. 64 was drawn

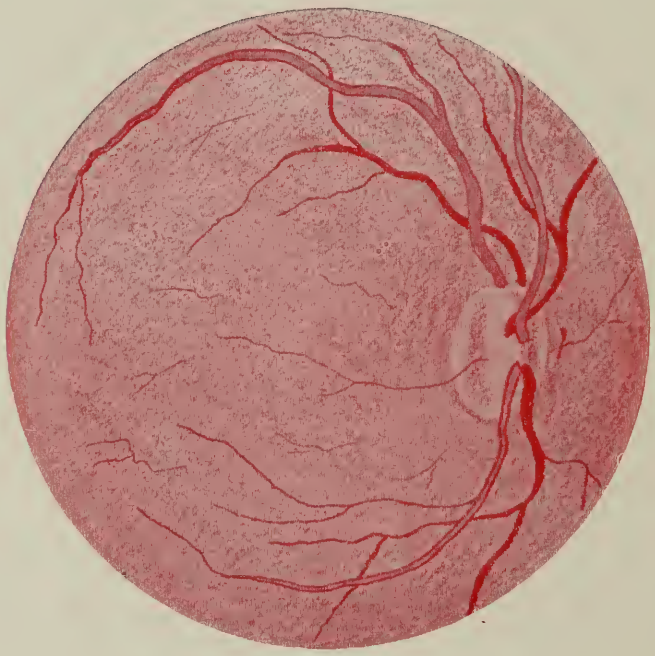


Fig. 64

from an eye alleged to be glaucomatous, but + 2.50 lenses removed all the other symptoms and the patient is still happy after nine years. The fairy stories about glaucoma, its causes and cures, are enough to make angels weep. One writer declared he caused it in one week with atropine and cured it the next week with eserine. A reputable ophthalmic paper printed the story too.

If there are several diopters of astigmatism the disk may appear blurred in one meridian but clear in the opposite one, when turning the lenses of the instrument will reverse the appearance.

Retinitis begins at the edge of the disk so far as appearance goes and is sometimes so intense as to obscure the edge as shown in Fig. 65, which also shows the choking of the vessels often associated with dysmenorrhoea.

Fig. 65

In advanced stages of Bright's disease there will be found, in addition to the diffuse inflammation, first small pus-patches followed by a dry, white appearance (Fig. 66), which in turn is succeeded by black patches (Fig. 67), due to disintegration of retinal tissue exposing the pigment; in the last stage all three exhibits are present.

In syphilitic retinal affections there are black fantastic figures, like spider webs, fern leaves or ink splashes, with no inflammation unless there chances to be kidney trouble, which is rare.

Obstructions in vessels show congestion as in Fig. 68. Pressure is liable to rupture the vessels when the extravasated blood would spread out and coagulate, at least temporarily destroying vision. In time, however, reabsorption may occur and vision be restored.

Fig. 66

In chlorosis, although the cheeks may be rosy, the internal view discloses pale arteries and dark veins, with a lack of quantity in both. Such cases complain of general tired feelings and confess to attacks of faintness.

Dark arterial blood means the liver is not working, and even when the arteries are pretty good color, if the veins are unusually dark, look for a coated tongue.

Be sure to look for the "yellow spot of Soemmering," in every case. If you find it, I am a liar. If you don't find it, Soemmering and his tribe are. The posterior pole has a field around it upon which images must be formed to be seen clearly, but there is no more color to it than there is to any of the other parts. It is more free from large vessels, but there is no other distinguishing feature. Some other German professor should come along and tell us he sees the pole.

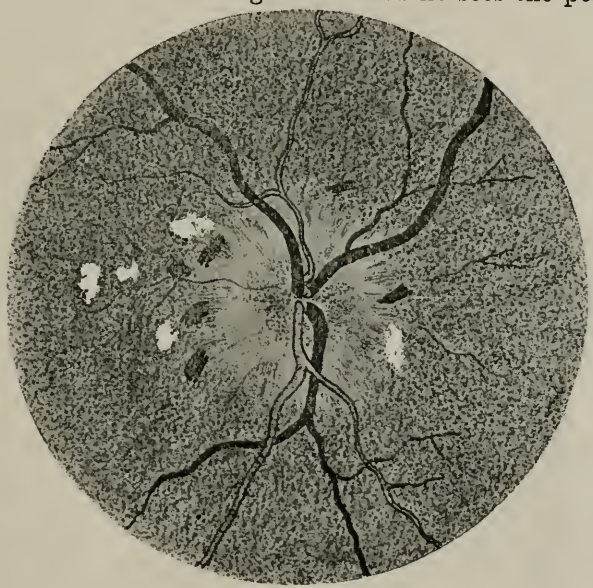


Fig. 67

Do not take anyone's word for anything except where it is exclusively a matter of veracity—and go slow on that. Learn by practice what constitutes a normal retina, and when there is departure, you will know it without pictures as guides.

Retinascopy, skiascopy, skiametry, pupiloscopy, koroscopy, and the shadow test, are synonymous. It is an objective method. While they work well on schematic eyes, which are fixed dioptric systems, it is a physiological impossibility for them to be used with any degree of accuracy in fitting glasses, because the intense light thrown in the eyes sets the accommodation and iris to work at once, the pupil becomes

Fig. 68

smaller and the dioptric system is changed decidedly, decreasing hyperopia, increasing myopia and making emmetropia myopia.

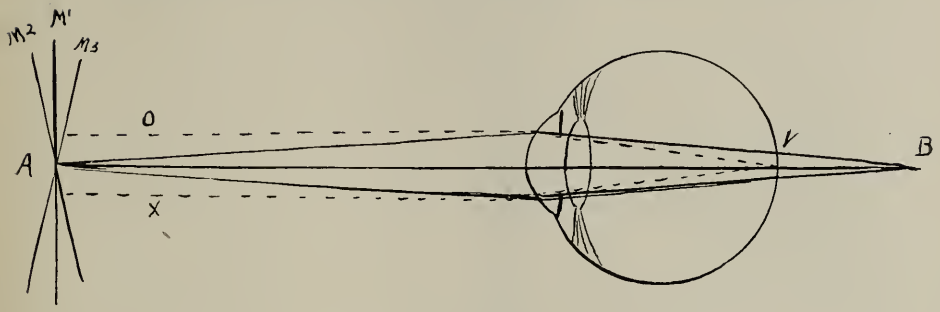


Fig. 69

Fig. 69 will be of service in explaining the action of the principle. The three lines crossing the axis at A represent three positions of the mirror. Fig. 70 is a mirror, it being in this instance a plane one. The light being reflected from the morror M' at A Fig. 69 would focus at B if it could get there, but as the retina is in the way there are circles of diffusion formed at V and the light comes back from those circles over the lines upon which it entered, also along the dotted lines O and X and in all the space between them, so that the entire pupil is illuminated. By tilting the mirror back to M^2 the dotted line O becomes the line V A, and the original line, with all the rest, drops below the axis at the peep-hole so the only illumination comes from the upper part of the pupil, the rest being in eclipse—this is the shadow that follows the movement of the mirror in hyperopia, emmetropia and myopia of less amount than the equivalent of the working distance. If the mirror be tilted to the position M^3 the line X will become the line B A, and all the rest will be above the axis at the peep-hole. The + lens which will bring the dotted lines down the black lines' course to A is the measure of the defect plus

Fig. 70

the working distance. The light may be thrown across the pupil vertically, horizontally or obliquely, and if the shadow moves with the operator's movement of the mirror + lenses will be required. If too much is put on it will cause the movement of the shadow to be against the mirror movement because the rays O and X will cross before they reach the peep-hole.

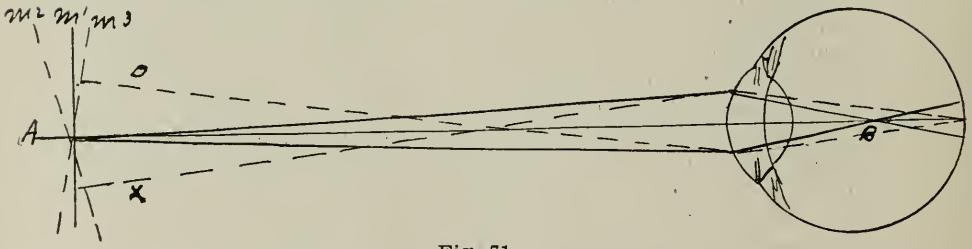


Fig. 71

Fig. 71 shows how the same mirror works on highly myopic eyes. The rays reflected from the mirror M^1 at A focus at B, and form circles of diffusion at the retina. The

rays return along the black lines, the dotted lines, and from all the space between the black lines at the retina to all space between the dotted lines at the mirror. Tilting the mirror to M^2 raises the illuminated field at the retina and lowers the field at the mirror so that the ray O falls into the peep-hole while the rest drop below, but as this ray comes from the lower part of the pupil, which is the illuminated portion, the shadow movement is against the mirror. Tilt the mirror to M^3 and all the rays returning to the mirror will rise and X will fall into the peep-hole, the shadow will move up as the light is turned downward at the eye. The — lens which will cause the dotted lines to diverge until they only meet at the peep-hole will be the correction, minus the working distance. After finding the lens which stops the shadow, or in other words brings the observed retina in conjugate focus with the observer's, if the lenses are + they must be reduced the equivalent of the working distance and if — they must be increased that amount. That is, if the working distance is 20 inches the + lenses will be 2.00 D. too strong, and the — lenses will be 2.00 D. too weak. If the + lenses are less than 2.00 D. the eye is myopic the amount of the difference between the power of the lens and 2.00. Or, again, after getting the correction, + or —, hold a — sphere equal to the working distance, in front of the lens or combination, to give good distant vision.

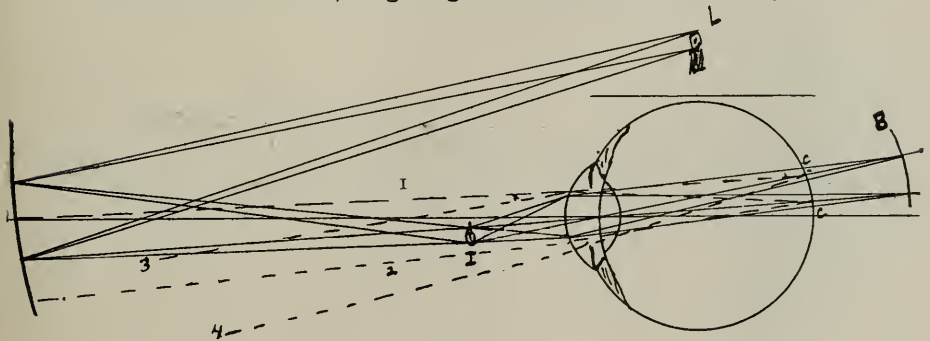


Fig. 72

If the concave mirror is used the effects will be reversed, the shadow will move against the mirror movement in hyperopia, emmetropia and in myopia less than the working distance. Fig. 72 will give a pretty clear idea of how the light gets into and out of the eye by this method. It is decidedly more complicated than with the plane mirror, but the result is the same because it is the light coming out that the operator has to deal with. Rays from the light L, to the mirror are reflected to the point I where an image is formed which becomes the real light so far as the eye is concerned, the rays from which would focus at B, if they could get there, but they form circles of diffusion from C to C and the light is reflected as shown from lower C along the dotted lines 1-2, and from upper C along the dotted lines 3-4. It will be seen that with the light I below the axis the circles of diffusion between C-C will be above the axis and all the light that strikes the peephole in the mirror must come from the vicinity of lower C and follow dotted lines 1 and 3 and all in the space between. Turning the mirror so that the light I is above the axis will put the circles C-C below and the rays from C-C at their new position

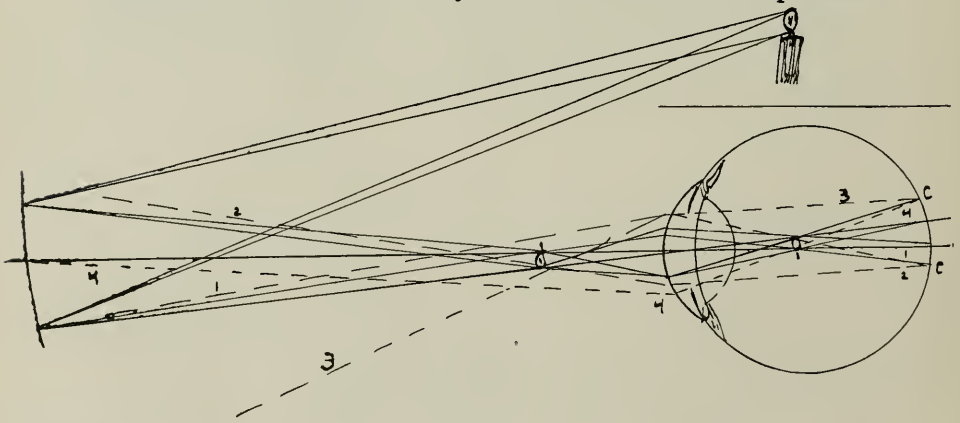


Fig. 73

will follow the dotted lines 2 and 4 and all in the space between as they are raised toward the peep-hole. Of course the shadow in on the opposite side; and, as shown in the cut, the shadow comes up as the mirror is turned down.

If the eye is highly myopic a new feature presents itself. The mirror forms an image in front of the eye, the dioptric system forms an image of the first one, which has become the real light to it, then the rays pass back to the retina and form circles between C-C. (Fig. 73.) The dotted lines 1-2 and 3-4 show the course of the emergent rays. In the position shown the mirror is throwing the light just below the axis and the image in the eye is just above the axis; the light that gets in the peep-hole follows the line 4-4-4, hence the illumination is below and the shadow moves with the mirror movement. Turn the mirror up so it forms the image above the axis, the one in the eye will be below, the circles will drop down and the illumination will follow the line 1-1 which will then be in the same position above the axis that 4 is below, as shown in cut, thus the illumination will come from the upper part of the pupil and the shadow follow from below, with the mirror movement.

I have given space to this story because it has never been told in detail before. As a means of measuring errors of re-

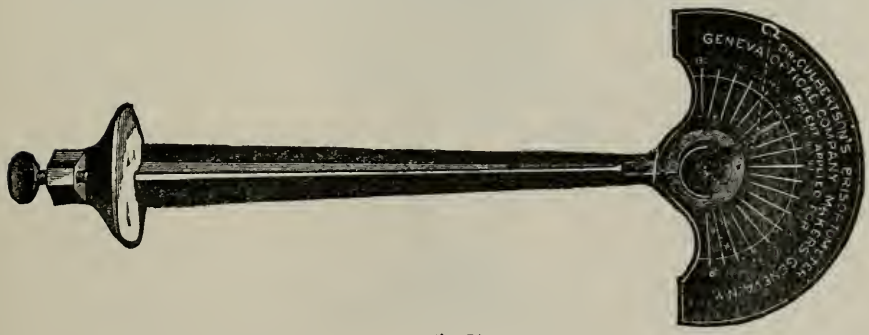


Fig. 74

fraction retinascopy is worthless on account of the physiological obstacles mentioned in the beginning. When anyone says he can fit eyes by the method he is a humbug, and the worst of it is, he humbugs himself.

The prisoptometer, Fig. 74, is a subjective method of attempting to measure errors, but it is very unreliable, for two reasons: First, the operator is compelled to rely on what the patient tells him, with reference to the targets; second, the test is a monocular one and there is a constant tendency to induce rather than suspend accommodation.

The ophthalmometer, Fig. 75, is an objective test and is an imposing appearing instrument to those who are in awe of apparatus, but it attempts a geometric impossibility in its principle, proposing, with a fixed spherical curvature in itself, to measure a variety of spherical and ellipsoidal curvatures in others. Its makers only claim it will register the axis exactly and approximate the amount of astigmatism. When one considers the fact that oblique astigmatism is sometimes exhibited by spasm or exhaustion of the nerve supply to the oblique

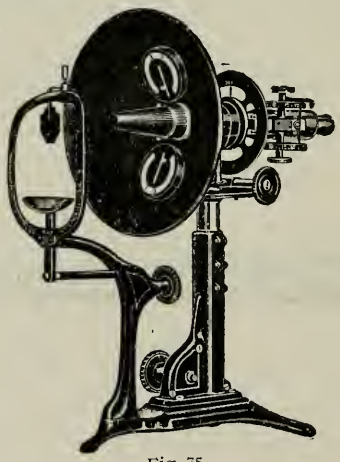


Fig. 75

muscles; that approximates to the amounts of astigmatism are not what a good doctor is looking for; that all work done by it has to be done over by subjective methods; that it is expensive and that it is monocular, the conclusion is reached quickly that the price of it would be better employed in some other manner.

The stigmatometer is both an objective and subjective instrument, it embodies many excellent physical principles, and is a compliment to its young inventor. The only faults I find with it are: First, it is monocular; second, it is expensive; third, it is not practical for many of the same reasons other machines are not. It may do for opticians or oculists, but neurologists and ophthalmologists, who are worthy of the name, have no use for such things, as they take valuable time that can be devoted to more effective methods which only cost money as education is paid for.

Phorometers, optometers, refractometers, and all similar devices are worth more to the makers and sellers than to anyone else.

The perimeter is all right in a school room or for experimental purposes, but in the doctor's office it is of less value than a retinascope.

A good platform scale is worth more than a cart-load of the instruments enumerated after the ophthalmoscope, which is really a necessity.

ABOUT ALLEGED EYE DISEASES.

Suggestions for Simple, Rational Procedure Instead of the Old-School Frenzied Methods.

When we talk from the standpoint of the old schools, we should call everything disease except emmetropia. Hyperopia would be a disease because it produces discomfort. Right here we have one of the greatest proofs that the old schools lack method and foundation, because if disease is the cause of troubles, the inflammations, hypertrophies, paralyses, and atrophies produced by the efforts to overcome hyperopia, which are treated by them as original diseases, benign, malignant, contagious, or infectious, are merely the effects of diseases, therefore not the causes.

Hyperopia is a simple lack of development of the visual organs, and it is no more uncommon than the lack of development of the nose-bridge; the reason it causes more trouble is the existence of a mechanism by which it can be overcome largely, therefore hyperopia makes necessary nervous activity in excess of normal, and as the daily amperage is increased from 1,000,000 units 23 per cent. for each unit of hyperopia, it means that to sustain this extra amount a greater voltage has to be turned on from the cerebellum, and, as that voltage cannot be applied to the eyes alone, it necessarily involves the entire system, which is practically on one circuit, and it becomes easier to short-circuit a high voltage; even if it is not short-circuited, it will increase the temperature throughout, particularly in the end organs, that is, where the sphincter muscles are located. Then follows congestion of blood vessels, particularly in those regions, and we have external and internal inflammations, the former being more alarming to the laity and ignorant doctors because it looks fierce, and because it has the additional irritation from atmospheric changes and from maltreatment by the patient, who rubs it, or scratches, or ap-

plies remedies suggested by "buttinskies;" the internal effects are certainly the worst, because, although protected from the secondary disturbers, described above, they are for the same reason less liable to occur from the original cause alone, hence when they do occur, the situation is more serious. Our treatment is practically the same for both, part of which is to require the patient to stay indoors, to avoid in the first case the atmospheric changes, and in the second case, to prevent continued use of the machinery which is producing such bad results.

Of course, for the external troubles, we apply cold salt water compresses to antiseptisize and reduce the temperature; but it is our internal chemical treatment through dieting, the mechanical manipulation and the glasses which correct the hyperopia that remove all the effects. For the internal effects, which we know are by far the most serious, if there is pain, we apply hot water compresses sometimes alternating with cold, if the hot does not give relief pretty quickly and if the pupil is small it does no harm to dilate it with atropine and may prevent adhesion of the iris and lens. It has no effect on the cause but merely dilates the pupil, to make it clear the apex of the lens.

In order to differentiate external and internal eye troubles take the following symptoms and what they mean:

External—Looks badly. Is not dangerous unless neglected. Does not impair vision. Is not painful. Appearance sometimes causes nausea, when patient sees it in mirror. Is sometimes itchy or smarts. Hypertrophy or pterygium or pannus may result. Does not affect accommodation.

Internal—Does not look badly. Is dangerous. Affects vision, because retina is influenced. Is painful from ciliary cramps. Does not nauseate. Does not itch or smart. No such thing as hypertrophy is possible. Always affects accommodation.

Double symptoms mean both.

Retinitis is not always discoverable with the ophthalmo-

scope, therefore when it is thus seen, it has reached a serious stage and no patient should be allowed to use the eyes while that symptom is present. Any unusual sensitiveness of the retina, except that indicated by keen vision, indicates retinitis. There are two kinds of that seen by the ophthalmoscope. First, that which begins at the edge of the disk; second, that caused by congestion of the choroidal vessels, thus putting pressure on retinal vessels at certain places, which will exhibit themselves by retinitis, with a center of its own independent of the disk, marked by a little blood clot. This is the wonderful "choroidic-retinitis." What is known as neuro-retinitis or choked-disk is only found in females with amenorrhoea or dysmenorrhea, or, in other words, tonic spasm of the sphincter system, in at least 98 per cent. of the cases. The primary cause is hyperopia, but the general involvement of the entire system puts it beyond the power of the eye correction to cure; however even the optician who has sense enough to fog vision with plus lenses will do absolutely no harm and infinitely more good than the old school physician or surgeon, with their drugs and knives. Their criminal ignorance of physics and dietetics, manual treatments, etc., are an indelible blot on the American Association of Medical Colleges, whose product have removed ovaries in their endeavors to relieve effects of what was really nothing but ulcerated teeth; who have castrated thousands of women to relieve effects that were really caused by hyperopia. The proof lies in two facts, first, their own records show they have uniformly failed; second, hundreds of graduates in neurology and ophthalmology have not only procured the cure of all cases not operated or doped, and have relieved almost completely nearly all of those who came to them after having survived the operations and doping. This particular neuritis exhibits an intense inflammation around the disk, so that the edge is obscured by the congestion. The arteries will be practically empty and the veins very much congested, both because of the cramp around the optic nerve entrance which is also the entrance of the retinal branches of the ophthalmic artery and the exit of the branches of the ophthalmic vein.

A retinitis that is frequently found in both males and females, but more frequently in the former, is somewhat similar to the above described, with the exception that there is no emptying of the arteries, rarely congestion of the veins to the extent of thrombolism or embolism (the result of plugging) and the inflammation around the disk is more widespread. It has been called albuminuric retinitis, meaning incipient Bright's disease, and if allowed to continue, the disorder increases, eventually exhibiting yellowish patches to be followed at the next stage by white ones and finally by black ones; of course when the black appear in one part, another may exhibit white, another yellow patches, and the rest simple inflammation; but we know by the exhibit the stage of progress of the so-called disease. The alleged oculist who examines by the indirect method would never see these things because he could not; the direct method is as superior to the indirect as truth is to falsehood, or as a person is to his picture. Here is where the neurologist is so far ahead of general practitioner and oculist, that there is no comparison, neither of these doctors is competent to recognize the disease so soon, and neither is competent to treat it in a simple effective manner, because they labor under the impression it is a kidney disease, when if we were going to call it a disease at all, we would be compelled to say it was a liver disease, for the kidneys cannot possibly suffer if the liver is performing its functions normally; but we cannot call it a liver disease, because the liver disturbance is always produced by being overloaded, from the portal circulation, which comes from the stomach, spleen, mesenteries and intestines, in other words the digestive apparatus; we cannot call it a disease thereof, because this apparatus was compelled to handle the food that was put in it; we cannot call it a disease of the food—because nature combined the elements in proper order, hence the fault was from the patient, in his ignorance, putting into the apparatus a wrong quantity or a wrong combination of chemical elements, thus producing all of the disorders. Thus we might prove from one standpoint that all

diseases are mental, and that all cures must be mental, that is, remedy the ignorance and the administration of functions will be consistent with nature. On the other hand, we explode the faith cure, the suggestion idea, the dope feature, and all the mysterious humbug theories extant, because we see the faith healers and their votaries sicken and die; we see the chief exponent of suggestive therapeutics lose his wife by suicide; we see the dope doctors put in kidney remedies, and ignore the liver; we see the mysterious practitioner make himself ridiculous by his glaring ignorance.

Neurology teaches we must make no claims that we cannot establish beyond question, it teaches there is a limit angle not only to what men can do, in the way of assisting nature to restore health, but there is also a limit-angle to Nature's capacity, and when it is passed she goes down to the death of the patient, which is as natural as for her to go the other way when the case is within the limit angle of human assistance; therefore when a patient recovers under our ministrations we congratulate ourselves that we did not hamper Nature and that we rendered only such assistance as we knew positively, mathematically, would assist her and we ascribe all the credit to Nature for making such laws and permitting us to discover as much as we have, and to the patient for exhibiting sense enough to follow instruction strictly, thus insuring the greatest possible benefits without any probable interference with nature. We have learned that when the second, third and fourth stages are reached the case has increased in malignancy in the ratio that the figures bear to one—for instance:

1—Simple inflammation.

2—Yellow spots.

3—Yellow and white.

4—Yellow, white and black spots.

There are always at least two effects from any disorder of the machinery, the one described above is the product of chemical poisoning. Another is the clogging of the machinery, so that its functions stop entirely; for example, the accumulations

of sugar in the liver interfere with its working and much of it passes on to the kidneys, clogging them also. At first there may be polyuria succeeded by the desire to void urine, but inability to do so on account of the sugar deposits. When it reaches this stage it kills quickly, on the same principle that one chokes to death. The eye indications are objective and subjective, the patient will complain of floating specks (muscae volitantes); with the ophthalmoscope we see a dappled or greenish streaked appearance of the retina with no inflammation. If this appearance should be accompanied by inflammation, we would know that there was complication and that both effects, that is, auto-intoxication and clogging were present. Such patients always confess to a sweet tooth and nearly always have bad teeth. Of course, correcting the errors of refraction in such a case could not begin to assist Nature enough to effect a cure. The oculist and optician do not know this, and the case is not only a failure in the respect of getting eye benefits, but it goes on to its death through their ignorance by getting beyond the limit-angle before seeking other assistance. The ophthalmologist (the real one, not the one who merely calls himself such) knows what this means and in addition to prescribing lenses he regulates the diet quantitatively and to some extent qualitatively, but the neurologist goes clear down the line in every detail.

So-called "retinitis syphilitica" is notable for the absence of the "itis." Retinitis syphilitica presents peculiar fantastic appearance, sometimes like fern leaves, at others like little black lakes connected by canals. It begins well forward near the edge of the ciliary body, out of possible view by the indirect examination, and works its way backward toward the macula, until a patient looking at the line "C. L. D." on the test card, for example, can only see the "L." or one letter at a time, so small is the field of vision; it is quite frequently found in children, and is of course congenital; it also occurs in those who have had syphilis, and if it takes this form of sensation interference, it rarely if ever develops motor trouble,

while if it attacks the motor nerves, producing ataxia, it rarely, if ever, develops the other form. The probable reason is, that the chemical reactions are of such a nature that the line of least resistance in one case is sensory and in the other is motor; or, in other words, in one instance the chemical reactions are not sufficient to produce motor energy and in the other are insufficient for sensory energy. All we can do in either case is to get the best possible chemical situation; so that nature may arrest the progress in either case.

Sometimes there will be intense injection of a vessel, so that it appears puffed almost to the bursting point; this occurs as a product of a condition of the blood in which the formation of emboli or thrombi (plugs) occurs; the current of the arteries being from the disk the embolus is always at the farther end of the swollen place; the current of the veins being toward the disk the thrombus is always at the nearer end of the swelling; manipulation of the eye ball, therefore, might displace the plug in the vein because it would push it toward the larger opening; but it would only tighten the plug in an artery; in either case there is danger of rupturing the vessels, therefore the best way is to attack it chemically, requiring absolute rest and using abundance of salt in the diet; the latter does not thin the blood, as is popularly imagined, it merely reduces the lymph or plasma or liquor sanguinis to a normal liquid state, thus the plugs are dissolved. If hemorrhage has already occurred, the extravasated blood will be seen as a sort of a splash, almost at right angles to the vessel, and from five to fifteen or twenty times as wide; this is provided the hyaloid membrane is intact, otherwise the vitreous will be discolored and little or nothing can be seen with the ophthalmoscope; if the hemorrhage occurred so long before we see it that reabsorption has taken place there will be white streaks alongside the vessel produced by the emptying of capillaries which collapsed and never refilled.

By examining one another's eyes in class and by examining not only patients, but persons supposed to be in perfect

health, blondes and brunettes, young, middle aged and old, males and females, we learn the average size of the vessels; the normal color, and are thus able to recognize instantly any deficiency in the quantity or quality of the arterial system, which represents the entire body and we know when the veins are too dark, indicating a lazy liver. We recognize anaemia by the arteries and the toxic condition, commonly known as malaria, by the veins; by incidentally catching a whiff of the breath of the patient, we can distinguish catarrh or acute liver disorder, or a simple temporary stomach disorder; catarrh has a dirty black odor, something like a morgue, the bad liver has a dark brown odor, while simple indigestion is either a mild gray or a sloppy yellow odor. It will also be found that in healthy children the arteries and veins are so nearly alike we distinguish them only by the veins being larger, therefore any child presenting the appearance of an older person, is not in perfect order, and the older person presenting the appearance of a child is in prime condition. As we grow quite old, long past the age of maturity, the amount of carbon dioxide increases even in health, making the veins quite dark, while the arteries are somewhat paler than middle age. For corroboration, let an old person sleep in a close room, and two healthy children in another of the same size, then compare the two rooms next morning.

In myopes the vessels usually appear large for two reasons: First, they usually are larger; second, we observe them through a more powerful dioptric system. In hyperopes they often appear smaller, because, first, they often are; second, because we are looking through a weaker dioptric system. While we may observe the general systemic system through one eye, we should examine both eyes to observe local conditions. If one eye has normal vessels and the other has very small ones, it indicates vision in that eye will not be good, and there will be little hope of improving it. There will also be noted a decided difference in the size of the disk. Sometimes we find both eyes much undeveloped, and we rarely get normal vision.

If there is a vast difference in the two eyes, yet the apparently undeveloped one is highly astigmatic, there is more hope of development, and if the internal appearance is about equal, the chances are good for development. This is, of course, not all due to the glasses, but the systematic treatment would be fruitless without them.

One of our means of noting the progress of a case, is by observing the blood, and we hold that no doctor, of whatever school, is competent to practice justly to himself or patient, without understanding practically the ophthalmoscope, how to fit glasses, manual therapy, dietetics and the power of mind over matter.

If there are wart-like dilations of the vessel they indicate a dangerous condition of the walls and a lack of the elements necessary for strength in them. These dilations are called aneurisms and they are doubtless present elsewhere in the body with great liability of fatal termination from interstitial hemorrhages. We pile in the plus foods and keep the patient extra quiet, reduce flesh and increase the strength.

If everything appears normal, but the vision is bad and cannot be fixed, there may be atrophy of the main trunk of the nerve, or of the fine branches forming the macula. We decide between atrophy and paralysis by the patient's story, if vision was lost suddenly it could not be atrophy, if it went slowly it could not be anything else, provided the media are clear.

Of course opacities of the cornea, aqueous, crystalline or vitreous impair vision, and if in the crystalline humor the term "cataract" is applied, if in the vitreous or aqueous, it is called a "nebula," meaning cloud, or a "macula," meaning spot. These terms are also applied to some corneal opacities, although they are more frequently termed cicatrixes, meaning scars, because they usually come from ulcers. Sometimes there are blind spots at the retina, which at times interfere with vision to some extent; for instance, a person looking at the test card would see all the letters except at the lower left, upper right or some small part of the field. This is called a

"scotoma." Or, it may cover one-half of the field; for instance, if a patient with his right eye would see the left half of the card, it would be called "hemiopsia" or "hemianopsia."

Myopia is an overdevelopment of the globe, or increased volume of vitreous, so that the principal focus is in front of the retina; in case of general overdevelopment there may be very good vision with correct glasses, but if the eyes appear to be overdeveloped, while the rest of the person is undersized, we are suspicious it belongs to the class of increasing volume of vitreous, hence naturally progressive and malignant; therefore, unless we make such systemic changes as will stop the tendency, there will be posterior staphyloma, which means a bulging of the posterior pole, from intraocular pressure, with the result that the retina will be torn and the macula destroyed. If we get a case that has already reached a decidedly progressive condition, the large vessels, which meet in the center of the disk normally, will make a right angle turn toward the nose in the field of the disk, and at the temporal edge of the disk there will be a well-defined white meniscus. This is called the myopic crescent. If the staphyloma has reached a bad stage, there will be a great patch at the posterior pole, possibly interspersed with fragments of pigment and little blood clots. .Vision will be very bad and little or nothing can be done for it. There is another form of myopia in which the eyes are very small, but shaped like an acorn or pecan, hence the myopia. These will be found in persons who are congenitally deficient in every other respect, and the majority of cases thus far found, have been the children of diminutive parents, or of diseased ones, and it is not unusual for females of this class to have dysmenorrhea, vicarious menstruation, violent tempers and end in insanity.

There are physiological appearances, which sometimes disturb the beginner, but which need not when the characteristics are known. There may be great patches of pigment with smooth but irregular edges or the patches may be as white as the whitest porcelain; the large vessels will be seen to pass

under one edge, and out at the other without any inflammation or other pathological indications. Around the edge of the disk we frequently find pigment, because the layers are connected at that point and at the sclero-corneal margin, being in simple contact the rest of the way. Then there may be other exhibits, such as a speckled field, which has been called retinitis punctata albecens, in its pathologic form, but when found and vision is unimpaired, or can be made perfect with lenses, we know it is a physiological freak.

The so-called pulsating veins will always be found interlocked with an artery, so that the latter's impulse is felt by the vein at the crossing point and the congestion thus caused would lead to the belief a thrombus was present, except for the pulsation. Nothing can be done for it, and nothing is needed.

Pathologic conditions sometimes leave apparent physiological ones, or the latter may have been so situated as to impair vision or rather prevent its development from childhood. In such cases we watch it long enough to see that it is not progressive.

In high degrees of myopia, or in very old people with small pupils, it is sometimes difficult to see the fundus, because, in the first place, of the increased corneal curvature, reducing the limit angle of approach, and, in the second place, the smallness of the pupil. Nobody ever got too old to have their pupils dilated with atropine. Use No. 336 homatropine disks, 1-500 gr. each. For younger people use No. 338; or can be used on anybody.

The + and — lenses may be turned in for high degrees of error, but the first thing is to get the right angle of approach, which is from 15 to 20 degrees from the axis of the eye observed.

A pterygium is designated technically as a vascular thickening of the ocular conjunctiva. The conjunctiva is the membrane that lines the lids and covers the anterior portion of the globe, including the cornea; the part that lines the lids is the palpebral portion and that which covers the globe is the ocular

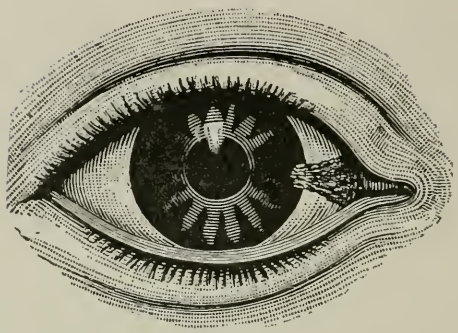


Fig. 76

portion. These growths are the products of irritation of the nervous system, produced from within by the strain of attempting to overcome hyperopia, and from without by the presence of fine dust, which accumulates in the nasal canthus because the flow of tears carries it there. The irritation of the nerves increases the heat in that vicinity and nature proceeds to build more blood vessels and to enlarge the ones already there in order to keep the membrane cool. They are easily arrested, if taken before they get too much of a start, by correcting the hyperopia, if any exists, and by using strong salt water with a delicate atomizer, twice a day for several days. Sometimes they disappear entirely. If they are neglected too long, and grow up over the cornea they impair vision permanently. Some malignant cases of long standing have to be dissected away. Fig. 76 shows one grown to the edge of the cornea.

Cataracts are opacities of the crystalline lens. They are of several forms, from that of a spider-web to a solid mass. The latter are seen easily and appear under an oblique illumination as a milky spot just behind the pupil. Congenital cataracts are those which exist at birth and are usually as white as ivory; traumatic cataracts are those caused by blows and they may mature in a night; senile cataracts are those which

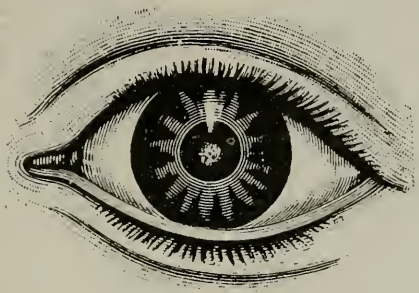


Fig. 77

come in the eyes of old people from the systemic changes incident to their age. Fig. 77 shows a cataract in the center of the pupil.

Formerly the only remedy was operation, and that often failed to restore sight because the retinal connections with the brain had become atrophied from non-use. It is not advisable to operate as long as the other eye is usable.

Some success has been had from the use of succus cineraria maritima, some from oil of thuja cxidentalis, and some from a saturated solution of common salt. It requires about three months to make the latter. All of them are used in the same manner, that is, a drop on the cornea, just above the pupil, three times a day. They enjoy about the same per cent of success as do other chemicals, medicines, etc., and no one knows why they work when they do or why they fail when they do that.

CLINICAL HINTS.

Have a private office and when admitting friends and relatives of patients have the seat they are to occupy screwed to the floor. Never have more than one extra person in at a time and have a strict understanding at the beginning that they are not to speak unless spoken to, explaining that the nervous system is a delicate thing which is liable to go + or — from causes produced by the operator, to say nothing of outside interference.

It pays to have a large and cheerful reception room with magazines and papers for the entertainment of guests and patients, and a neat reception girl to receive them.

Spend less time in your own reception room than anywhere else. If not busy with patients your work room is your place during work hours.

Free consultation is proper, but limit it to fifteen minutes, during which you can make an estimate of the case, state the amount of your fee, and how it is to be paid; require a portion of it paid at once to bind the appointment for the examination, stating to the patient that you have been compelled to make this arrangement to apply to all equally for two reasons: First, to insure promptness in keeping the appointment; second, because some people will make an appointment when they know they cannot pay the fee and do not want to, hence have no intention of keeping it.

Have a distinct understanding that when you take a case and have specified the time they are to be in your care, the patient having agreed, you will tolerate no interference or suggestions from relatives, alleged friends and others commonly known as "buttinskies."

When a patient attempts to argue or to persuade you to change your methods to suit his convenience after you have made an analysis and found what is necessary, show the risk that both of you assume by it, and explain that these calcula-

tions are not the fads of a school of medicine, but are direct from infinity. If any fail to see the point, dismiss them; they are breeders of trouble.

The average heart-beats, forward and back, in the adult are about 80 per minute; in children they are somewhat more frequent, and in the aged are slower. Therefore, when we find a grown person's heart running rapidly it indicates irritation of the nerve supply, and if we find that of a child running slowly it suggests weakness or an unusual slowness for physiological reasons; such children are usually termed phlegmatic, opposed to nervous. When the heart is unusually slow or rapid, keep the ear to the chest for several minutes to see that the rhythm is perfect, which is the main thing. The very rapid hearts often drop a beat in five or ten and usually begin strong and taper down until they drop a beat; those are positively not mitral valve troubles, nor do they involve any of the valves of the heart as causative factors. The whole trouble is in the weak nerve supply, as may be readily proved by having the patient lie flat on a table or the floor for ten minutes. The cause of the nerve weakness may be in one of many departments.

After taking the data upon which your prescription is to be based, unless the case is a very simple one, take a day to figure it out, in the meantime requiring absolute rest, and it is not a confession of incompetence to repeat some tests on a second visit. It is easy to explain to the patient by showing the sheet upon which the calculations were made that this is part of our method of procedure which enables us to be sure we are right.

The matter of diet should be figured out by taking the principal things they have been eating, casting up the points of carbon, nitrates, phosphates and water and preparing the diet so that the figures reverse, to whatever extent we deem necessary; that is, if what they have been eating runs four points carbon to one or two points nitrates and phosphates combined, we make the change at first so that there will be two

points of nitrates and phosphates to one of carbon, explaining to the patient that from time to time the proportion of carbon should increase, but never be allowed to get as high as it was. See book "Neurology and Metaphysics."

Children and old people require more delicate handling mentally and physically than those between 20 and 50, because the children are not yet matured and old folks are on the decline. Of course there is a difference in individual cases, even in those classes.

After the age of fifty if everyone would cut out starchy foods, sweets, such as pastry and all breakfast foods, subsisting largely on nuts and vegetables in summer, with occasionally smoked meats, fish, and with a moderate amount of other meat in winter, they would come as near having the elixir of life as has yet been discovered.

Never forget to wash the hands with soap and water, rinse them and clean the finger nails before beginning work on a patient. The odor from sweaty hands is offensive. After a patient has left the operating room open a window and spray a little perfumed water about.

In prescribing temporary lenses for neurasthenics in whom fogging causes nausea remember they are mentally as well as physically weak, and reduce the fog to the comfort point, but keep it as strong as you can. Fog all others 20/80, or even more, because they are not nearly as liable to look over the glasses as if you gave them 20/30 vision, and their distant vision will be almost as good, while it is still a constant reminder of the doctor's orders.

Beware of prescribing cylinders when they are — .50 or — .75 or less. The way to get around it is, after proving say a — .75 ax. 180, slip it off, hold it in one hand and have a — .25 sphere in the other, the patient looking at the test card; hold the cylinder in front first, then take it away and try the sphere; if vision is not so good, compare the cylinder with a — .50 sphere, if vision is best with the cylinder, leave it; if best with the sphere, cut out the cylinder and reduce the + sphere

accordingly. If there is no + sphere in the combination, the rule will work just as well in the matter of substituting the sphere for the cylinder. In other words, theoretically, if a cylinder is correct it ought to give as good or better vision than a — sphere of the same strength, and the fact that practically in the amounts below one diopter it rarely gives better vision than a sphere .25 or .50 weaker is ample proof of the doubtfulness of weak cylindrical corrections. The fact that such patients see a difference in the radiating lines of the astigmatic chart without the cylinder has no influence, unless the patient is going to do such work as would involve such lines, and if he has been doing that work his vision will be so sensitive that he will never let us substitute the sphere in the first place.

Remember that presbyopia should not begin in emmetropes until between forty and fifty, and in hyperopes not until between forty-five and fifty-five, hence when we find one under the minimum age who seems to require reading glasses it is evidence of a nervous deficiency which should be rested, dieted, etc. Particularly with reference to hyperopes under forty-five who have say 1.00 D. or more error, but who have not worn glasses, and insist they only want them for reading, we explain that while they might be reasonably comfortable with such glasses for a while they are breeding trouble as certain as death or taxes, and in nine cases out of ten it begins at once, because the nerve supply being exhausted when the reading glasses are put on and the incoordination remaining between accommodation and convergence, comfort is almost an impossibility. Sometimes we make a concession to such people, which is to give them the glasses they should wear constantly, which of course will be some help for reading, and after explaining the above described situation, tell them when they find these are not comfortable or are irritable that it is a message from Nature telling them they must wear them all the time.

Never make bifocals for myopes, except possibly in a rare

case when the distant glass is — .50 or — .75, because in the higher amounts the prismatic effect is unpleasant on account of chromatic aberration. In making bifocals for others the scale for cements should be 13 mm. high, 15 mm. long, 1 mm. up from the lower edge of the lens; they may be set in a little, say 2 mm. toward the nose to suit the convergence while using them.

The pupil distance in glasses for hyperopes should be a trifle narrow than otherwise, because they are going to use them near and far, while for myopes they may be made full width.

Hook temples for glasses should be made long enough so that the tip is just concealed behind the lobe of the ear. Then there is no irritation from the pressure of the temple which is sometimes very annoying if they are made too short.

In cases where the eyes differ so much that one has been used to the exclusion of the other, or when there are oblique axes, the discomfort produced at first is so great that it may even cause sea-sickness. This should be explained previously so that the patient will not become frightened, and we should insist upon their sticking to them, when the trouble will be over in a few days, while otherwise it would last for weeks. The oculists who have perpetrated books call this the point of toleration and advise against prescribing for such. Toleration of drugs is one thing and of mechanical appliances another.

In working on cross-eyes when the patient complains of seeing double we know they are coming.

Sometimes in simple cases of hyperopia the patient returns in two or three days with a frightful looking case of congestion of the conjunctiva, for which there may be two causes or a combination of both; first, they may have caught cold and congestion centered in the eyes because it was a weak spot and offered the most resistance to the current, or the circles of diffusion at the retina caused by the lens and accommodation, from the myopia thus created, but the controlling center having been accustomed to turning on the power for circles of

diffusion tackled this one and the results are plain. Reassure the patient by making a drawing showing the story; have him go home and rest a day, using salt water, when he will be all right.

In prescribing applications for the eyes, remember that cold contracts and heat relaxes, therefore, hot water compresses are to be applied in cases of tonic spasm with pain. It would do no harm to salt it except that salt is an astringent, hence would have a tendency to counteract the action of the warmth, especially in the conjunctiva, through which part of the excess blood from the ciliary body finds its way to the veins of the face. Sometimes hot water does not accomplish the desired effect in a reasonable time, say an hour, then we alternate with cold, but not ice water. Another case in which we use hot water is when there is suppuration, the lids stick together and a wax forms among the lashes; hot water will dissolve this wax, which is impervious to the cold. It should be used with a soft cloth, and five minutes to each eye will make it perfectly clean; then apply cold salt water compresses for the purpose of cooling the temperature and for forcing the blood from the veins by contracting the nerves both from the cold and astringent effect of the salt, while the latter also antisepticizes the membrane and takes the gum out of the lachrymal fluid. In very bad cases of ulceration of the ocular conjunctiva, or granulation of the palpebral portion, they should be freely sprayed from an atomizer containing strong salt water, neither hot nor cold, about four times a day, a few good shots, one squarely against the eyeball, one under the upper lid and one on the under lid. The two latter may be made at one dash and should be directed toward the nasal canthus; then following this the patient should lie down and apply the cold salt water for a half hour. One of the treatments should be at bedtime, another the first thing in the morning.

In epilepsy, chorea or other nervous exhibits, remember they are not diseases, and the fact that drugs have failed in

curing them proves that they must be from mechanical causes, as that is the only classification left. It is true that under such conditions the chemistry of the stomach will be imperfect, and while many of the attacks come on after eating, still it is more mechanical than chemical even then, because they always have the fits in such cases just after overloading the stomach, thus proving that it is quantitative rather than a qualitative proposition. Of course we look after the eyes among other things, and we may safely devote more attention to mechanics even though as a matter of course we watch the quality as well as quantity of food.

The use of prisms as a treatment for cross-eyes is foolish, for so-called muscular insufficiencies, a misdemeanor, and to use them to prevent double vision is a felony, because it creates cross-eyes. Eyes may cross up or down, in or out, and the way a prism prevents double vision is by practically excluding one eye so that a so-called single vision is with the other alone and is not binocular.

Some very sensitive people occasionally complain of seeing every object with a sort of spot in the center, particularly small objects like letters, and sometimes they explain that there appear to be two objects, the ghost on top of the real. A young lawyer of Chicago came complaining of this symptom and said that a prominent oculist had made an examination and told him that he had had a hemorrhage in his left eye which left a spot of extravasated blood which caused the symptom. Inasmuch as the size of the retinal fieild occupied by the image of a small letter at twenty feet would be very small and the spot of blood would have to be smaller, something the size of a pin point, it struck me that the doctor was either a marvelous man or liar, and when the patient told me that if he covered one eye, it made no difference which, the spot disappeared, I became firm in the latter conclusion. Then he demanded an explanation from me. He was the most highly strung nervously of all the patients I have ever had and I reasoned that it must be a case of anisometropia, and as

vision was so keen with either I suggested that possibly he had .75 hyperopia in one eye and 1.25 hyperopia in the other or 1.00 in one eye and 1.50 in the other and when using both eyes together, accommodating the same amount in each, it left one under-corrected .50 or the other over-corrected .50, which would be just sufficient to make the ghost appear. After explaining this proposition to a class I used him as a clinic and found .75 hyperopia in one eye and 1.25 in the other and with these glasses on the ghost disappeared.

The last paragraph suggests another case which is not often found. It is possible sometimes to give a patient pretty good vision for distance with correction, but when it comes to the reading point no glasses will help and if the accommodation is active in a young person he cannot see to read. This is because a very small field in the center of the macula is healthy and sufficiently large to receive the small image of distant objects, but immediately outside of that there is a dead space, hence the larger images of near objects are not transmitted to the brain. Again a case may be found where distant vision is bad and cannot be improved, yet the patient can see reasonably well to read even without glasses. In this instance the situation is reversed; it is a central atrophy with a healthy periphery.

When a patient, or other person, happens to faint in your presence or have any kind of a falling fit, be careful to keep the body horizontal, if any change put the head the lowest, and apply cold water, either sprinkle, dash or use wet cloths. A bottle of strong pleasant perfume is better than camphor, ammonia or any other drugs. A sip of clear water is better than liquor and not half so liable to strangle. Manipulate the arms and legs a little, but be careful not to worry the patient. As soon as consciousness is restored a little pinch of salt or a swallow of lemonade will settle the stomach. In the convulsions of fits do not undertake to hold the patient rigid, but just keep him from hurting himself.

By way of illustrating the deviltry of prisms we have

the following showing the relative proportion of the total strain to the original impulse in an emmetrope whose convergence was irritated to the amount of 1.00 D. with a 4° prism and a hyperope of 1.00 D.

Convergence from 4° base out,	L. .50	
	R. .50	1.00 original impulse
Automatic accommodation,	L. 1.00	
	R. 1.00	2.00 automatic increase.
		3.00 total damage.

Increase over original impulse, 200 per cent.

Effect of hyperopia:

For accommodation,	L. 1.00	
	R. 1.00	2.00 original impulse.
Automatic convergence,	L. .50	
	R. .50	1.00 automatic incr.
Negative pull, 6th N.,	L. .50	
	R. .50	1.00 voluntary incr.
		4.00 total damage.

Increase over original impulse, 100 per cent.

The old-fogy idea that small pupils mean spasm and large pupils mean the reverse has caused the death of many persons from drugs administered wrongly. To us the significance of the size of the pupil is absolutely nothing unless corroborated in other directions. A small pupil may appear in a debilitated person who couldn't raise energy enough to have a spasm if he were paid for it, and a large pupil is very often found in people with a severe tonic spasm because the nerve branches operating the iris were put out of action by the ciliary disturbance.

In cases of very high degrees of hyperopia, say 6.00 D. to 10.00 D. we sometimes find after getting on all + we can that in adding for reading it takes considerable more increase of power than the reading distance calls for. For example, we

have found + 6.00 and have to add + 4.00 for reading at 13 inches. Our physics tells us this is wrong, so increase the + 6.00 to + 7.00 and find the patient sees as well at a distance as with the + 6.00, which proves once more that the Infinite Creator did not make a mistake.

Polyuria is not indication of kidney trouble in more than one-tenth of the cases it exhibits. It is most frequent in women and the old schools claim it is proof that they have more kidney trouble, when as a matter of fact they are notably free from it, and the symptom is nearly always due to a stricture of the muscular structure around the neck of the bladder due to sympathy with the accommodative effort caused by hyperopia.

Similar conditions in men usually mean the involvement of the prostate gland and irritation of the urethra, which is about eight inches long. In these cases while hyperopia is often a primary factor, sexual excitement intensifies the trouble and may cause it in emmetropes. The after-effects are incontinence, emissions, and finally impotence. The treatment for prostatitis, hydrocele, varicocele, urethritis, gonorrhoea, are all the same, a + diet, correction of eye errors, rest, avoidance of liquor and tobacco, sexual excitement and bougies. A fine-pointed rubber syringe may be introduced one-half or three-fourths of an inch and cool salt water injected night and morning; otherwise let it alone.

Pains are nearly always referred to a point comparatively remote from the primary cause; thus a disordered liver will cause a headache, and the pressure of a shoe on a corn will irritate the entire nervous system. But sometimes pain is referred to the seat of the primary cause by reflex action, as for instance in hyperopia the effort to overcome it by accommodation produces a tonic spasm throughout the entire system and the pain in the eyeballs is from the secondary irritation.

In questioning patients, do it deliberately, and form the habit of consecutiveness; that is, begin with the questions regarding memory, etc., headache, eyeaches, toothache, nose,

throat and ear affections, and so on down. Never ask a question without getting an answer; if the patient refuses, close the conference. If you ask to take the patient's glasses and he folds them up and puts them in his pocket, get the glasses, then deliberately lay them aside without looking at them and go on with your work. This is part of the true fogging system.

Quite frequently we have for patients young girls from the age of puberty to about twenty years, whose general appearance is healthy but who complain of a constant tired feeling, and the examination (ophthalmoscope), shows a very great lack of red arterial blood, while the venous blood may not be off color; the general field of the retina will be quite pale, and sometimes the larger veins may be extra dark. Such people will confess fainting spells or at least attacks of nausea and faintness, even if there is no swoon. They usually suffer from dysmenorrhoea and often menstruate every three weeks. Occasionally cases of the latter kind are found in people thirty-five years old, but such usually show debility in their countenance.

Boys between the ages of twelve and fifteen often go through peculiar systemic changes similar to those of girls, and not being able to find relief in menstruation, become so debilitated that they do not regain normal vigor until about twenty, unless they fall into our hands and go through a regular course.

Children who are growing actually need more food than grown people; first, because they have not only to sustain, but to build, the body; second, digestion with them is more vigorous unless it is suspended by overloading, and it is more difficult to overload them to that point because the muscular coat of the stomach is more elastic. If proper attention be paid to the quality of their food there will be a more even distribution and a greater return from the amount taken in the building up of the nerve and muscle supply, for the growing child needs more of the + elements than it does of the fat making ones, and with these supplied he will soon eat regu-

larly and not suffer the all-gone feeling a half hour or so before meals. But provide for such emergencies; let him have an apple or an orange, because it will not affect his appetite. See "Neurology and Metaphysics."

As to instruments for making eye tests, after the ophthalmoscope I would rather have a dollar stereoscope than all the phorometers, optometers, etc., on the market. It is made upon a physical principle with prisms base in that proves our physiological principles with reference to the meter angle of convergence caused by prisms base out or saved by prisms base in, and in case of tonic spasm exhibited by the + impulse in the static test, we might use such an instrument successfully sometimes in an effort to break down the spasm.

Referring to the eyes and their exhibits of spasms, we have two kinds, clonic and tonic; while the first is intermittent and the second constant, the latter being only a more intense form of the first, it may be understood readily that either may tend toward the other because the dividing line is not established like a pencil mark. For example, a tonic spasm may relax a little under our manipulation and thus become clonic while another case with clonic spasm may suddenly become tonic while we work on it. This may even go so far that the static test will show a + impulse before correction and a — impulse afterward, or the reverse. This is why we make the static test twice. Clonic spasm is expected in all cases under the presbyopic age, that is, under about forty-five years and when we do not find it at least moderately, it is sufficient proof of general weakness to require the patient to stop work. A moderate amount of it can be controlled by our systematic methods, mental and physical, and immoderate amounts are treated the same as tonic spasm because they are bordering on that extreme condition. Such cases should also be required to rest unless the dynamic test before and after correction guarantees a bountiful nerve supply.

While it is against the principles of ophthalmology to worry a patient by long-continued efforts to break down tonic

or clonic spasms, yet it is sometimes possible to accomplish it quickly by moving the patient closer to the test card, say ten or fifteen feet, when, everything being more distinct, his controlling center gets a better grip on it and we can at least measure and prove whether there is astigmatism; then after reducing the spheres until vision is what it should be at the distance the patient is seated, if the static test shows a + impulse we increase the spheres arbitrarily according to the neurometer instructions. Sometimes we find it best to not unfog the patient until he sees quite as perfectly as he should, and in such cases when it comes to adding for his + impulse we must allow about .25 for the amount already on.

Clonic spasm must not be confused with neurasthenia, as it is liable to be on account of one exhibit, that of seeing better one moment than another with the same lens; in the clonic spasm the patient may change a line or two or even more, but what he sees each time will be distinct, while in neurasthenia vision is fairly good one moment and the whole card fades away the next, while a sensation of nausea or faintness will be admitted; also the neurasthenic will exhibit this feature without glasses.

If the static test shows a — impulse it is either neurasthenia or a clonic spasm, but if the test shows a + impulse we would always class it as tonic spasm although in some cases we might be able to push it over into clonic and correct the error.

Clonic spasm signifies an exceeding irritation and very likely cyclitis, which requires rest, for two reasons: First, the possibility of local damage from adhesion of iris and lens in cases where the pupil is small, or possibly from infection of the conjunctiva or retina; second, the liability of causing cerebral hemorrhage from interference with circulation by the general spasm. This is more liable to occur in persons who are extraordinarily stout and who have reached the stage where they are highly nervous, because the walls of the blood-vessels are weaker, hence more liable to rupture. There is

also the possibility in thin people of cerebral paralysis and softening of the brain, or paresis, which is practically the same thing.

Catching a spasm at work is one thing and getting control of it is another. As we know the symptoms we know positively when we have controlled it and we also know positively when we have not. In the latter instance we fog the eyes and demand rest until the spasm breaks, or if we allow the patient to continue at work, which we should not do, we get a written contract that he assumes the responsibility.

The static test may show orthophoria from a tonic spasm in the 6th nerves as well as the 3d, but in such cases we would detect it by the pain intraocularly, or the test may register zero from a reasonably good supply of nerve force yet the case may develop quite a clonic spasm during the refraction test. Such cases are as a rule easily handled, although they are liable to deceive us into unfogging too much, unless we watch them carefully.

Don't forget that myopes are very liable to spasm from the accommodation coming automatically with extraordinary convergence, even though they show zero or — impulse by the static test. The possibilities of spasm in myopes of high degree are so great that if the patient is seated ten feet from the card without being able to see it, and we could get 10/15 vision with strong lenses, we would stop them at 10/80 if they had never worn glasses, or even if they had but were suffering from hyperopic symptoms, unless the general test combined showed such weakness as would warrant giving as much as 10/15 or 10/20, and even that must be supported by the fact that the lenses we give are so decidedly weaker than the ones they have been wearing that it is a clear case. It is nothing for us to steal a 2 D. or 3 D. from the — corrections of the average oculist or optician and still leave vision as good; therefore if we find a case where we cannot steal as much as a diopter and still preserve good vision we steal more and let the vision go.

In low degrees of myopia that have been fitted by other people, knowing their failings, we sail in to get + on, and in these cases, which are decidedly the worst of all we have to deal with, because they are liable to have a tonic spasm yet dodge all tests, we waste no time but fog to 20/80 or 20/120. An interesting thing about these cases is that while vision may be as bad as 20/60 with the naked eye we often get a + 2.00 on and vision be as good as 20/120, and we finally get as much as a + 1.50 cylinder or + 1.00 sphere + 1.00 cylinder, where the other fellow has — 1.00 or — 1.50 cylinder, and we sometimes get simple + spheres, + 1.50, where they have been wearing — 1.00 cylinders.

Having adopted the eyes as the gauges of the body, and utilized them as such, objectively and subjectively, the first, macroscopically and ophthalmoscopically, the second, dynamically and statically, we know that as a rule deep-set eyes or bulging eyes with a low nose bridge, vertical wrinkles in the forehead, etc., are objective symptoms that the gauges will need fixing. The subjective tests are equally simple when understood, and much more certain, indeed we diagnose objectively and analyze subjectively. Dynamic tests of the gauges mean different things at different ages and under different circumstances. The operator must be very familiar with these facts and know why the facts are. For example, children under ten years of age rarely show any more power by the dynamic test than those of that age, for two reasons, first: the eyes do not develop full growth and power until about the age of ten years; second, a ten-year-old can reach the limit angle of convergence, which is 2 3/4 inches, and the younger child could do no more, hence we begin our figures with that age and 14.00 D. Between ten and twenty years the child may have enough accommodation and convergent power above normal to overcome its hyperopia and come to the normal point, but when we put on the correcting + lenses it will not be able to show any greater power than before, because it has reached the limit angle of convergence, but we know that it has more power

than it shows with the lenses because it came to the same point or nearer without them. Example: Suppose a child shows 12.00 D. accommodation by coming to 3 1/4 inches without glasses, but by a test we find hyperopia of 2.00 D., we know that in order to come to 3 1/4 inches without glasses it must have been accommodating 14.00 D. and we give it such credit even if it can show only 11.00 D. with glasses on. If such a case shows an increase of accommodation after correction we know it should not be able to do so were it in good condition; therefore, it becomes a symptom of weakness in that child to show strength. Above the age of twenty years up to about thirty-five years, the near point recedes beyond the limit angle of convergence on account of the decrease in his dynamic facilities. We make the test before correction, then expect him to show an increase equal to the amount of + sphere in the correction. If he fails to do it, watch out for spasm, and if he shows more increase than he should it is a symptom of weakness which prevented him from showing as much as he ought to in the first place. After the age of thirty-five, when his near point is still farther away and his dynamics naturally weaker, we expect him to show an increase at the second dynamic test two or three times as great as the + sphere in the correction, until between forty-five and fifty, when presbyopia begins; therefore, if he fails to show an increase it tends to throw him into the next younger class, and is, therefore, a symptom of strength, or it may be one of many symptoms of great weakness. The way we differentiate the complication is, if a big, strong-looking fellow shows 6.00 or 7.00 D. accommodation at the first test, we know he is extra strong and do not expect any increase later, but if he starts in with only 3.00 D., 4.00 D. or 5.00 D. and appears to be presbyopic after correction so that he accepts addition for reading, yet is below forty-five years old, we take it as a symptom of weakness worth more than a half dozen symptoms of strength, and we order rest instead of adding for reading. This is of course subject to modification if the patient has been wearing glasses con-

stantly and the nature of his work, habits, etc., has been such as to produce presbyopia prematurely.

Briefly, if any one of these classes shows symptoms of the next older class it means weakness, and if he shows those of the next younger, it means strength. Of course the first class have no younger class and can go wrong only one way, while the middle class can go both ways, as can also the third class, because there is still a fourth in which the weakness exhibited is from natural presbyopia.

There are other ways in which the dynamic tests are valuable, which are set forth in the neurometer. First, when we make the first dynamic test we form a diagnostic opinion by combining it with the general appearance and history of the patient. Thus, if a child under twenty years shows only 6.00 D. or 7.00 D. accommodation, we know, looks or no looks, that it is in a bad fix, but if it shows 11.00 D. or 12.00 D., when we think it ought to show 14.00 D. we conclude it is either weak or is overcoming a great deal of hyperopia, and it amounts to a symptom of weakness in either case, which makes us wary. Or, if we find 7.00 D. in a person whom we think ought to show 10.00 D., it is a caution signal, although we may find the patient older than we think, and if we do, it is a reassuring symptom.

Sometimes as a matter of proof of our system we first take the dynamic test, then put on a pair of + 3.00 spheres and repeat the test, then ask the patient's age. From this data we proceed to figure out the amount of error that should be present. Thus a case showed by the first test 3½ inches or 11.00 D. Adding + 3.00 D. and repeating the test he shows 2½ inches or 16.00 D. Subtracting the + 3.00 from this leaves 13.00 D. to be credited to him; hence if he had 13.00 D. power with which he showed only 11.00 D. he must have been overcoming 2.00 D. hyperopia; or, after finding the 13.00 D. which indicates 12 years, 6 months by the neurometer, we added 10 years for mentality, which brought it up to 22 years, 6 months, then we asked his age, which was 29 years, 5 months, 8 days.

The difference between this and 22 years, 6 months, equals 6 years, 11 months, 8 days. The nearest to this amount shown by the neurometer is 6 years, 3 months for 1.75 hyperopia, or 7 years, 6 months for 1.50 hyperopia. We chose the former because it is nearer to the result of the short calculation. Hence by one calculation we found he should have 2.00 D. hyperopia and by the other 1.75 D. hyperopia. Of course this being found by the dynamic test alone was not as reliable as if we had completed the analysis, nor could we find astigmatism by this method, but it is one of the many things that go to make up the proof of the accuracy of our methods. A complete test of this case found 2.00 D. hyperopia.

Another dynamic feature in symptomatology is found in the reactions of the dynamics during the refraction test. If the patient sees better one moment than another with the same lenses, or if he improves a certain amount with a — .50 in front of the fogging lens and then requires more than that to improve an equal amount more, clonic spasm is indicated, or if he improves as much with a less amount of lens it also indicates clonic spasm, but at the same time we caught it on the reaction; but if in connection with the first named symptom, that is, seeing better one minute than another with the same lens, there is also nausea on the down turn, it signifies general weakness.

Another form of dynamic test is developed subjectively by cross-questioning. If a patient has a dry, itchy eye or difficult urination, or dysmenorrhoea, or piles, or even finds it difficult to swallow, they are symptoms of irritation, and we call them + because they signify sphincter contraction or spasm.

If the eyes are overflowing with tears or there is urinal incontinence, or if the menses are too frequent, even if there is dysmenorrhoea, or if there is constipation with a combination of other — symptoms, we know that it is due to nervous inability and that there is danger of a general paralysis.

Acute headache means spasm, but when they reach the

stage of sick headache it means exhaustion of the general supply. Dull, continuous headaches indicate an overworked liver and a consequent weakness of the nerve supply; but this symptom is rather one of caution and a suggestion to remove the pressure in order to find whether it is genuine weakness or only a temporary disability. In such cases as this it is best to demand a good fee, because while it may be temporary, hence quickly repaired, it is just as liable to be a chronic case. Of course we form final judgment by the general appearance, history, static tests, and the final analysis.

The first static test is that in which we delve into the history of the case, and as we also get some dynamic information from the history we must learn to separate the static from the dynamic symptoms as we go. For example: A patient tells, with reference to his occupation, that he does certain things, and the fact that he does them proves that he must have considerable force at his command, but when we ask him how he feels afterward and he says "It knocks me out," it becomes a static symptom of weakness which overbalances the other; then the two together form another symptom which tells us that his mentality is a dominating element which must be considered in the final calculation in figuring his age. Of course we must also find how quickly he recuperates after these excesses, and if for instance he wakes up refreshed the next morning, it is a + symptom, while if he is still tired it is a — symptom.

Again, if a patient does not report doing things, but on the contrary is doing practically nothing, yet complains of a constant weariness, it is a bad negative symptom; this is particularly true of young women, and it is quite common among them; and, for the reason it is rare among young men, it is serious when we find it.

Objectively the ophthalmoscope is a static test by which we ascertain the nourishing quality of the blood, knowing that the arteries should maintain about 80% red and have a light streak down the center, while the veins should have a darker

shade and the streak be fainter. In anaemia the arteries sometimes appear extra pale and the white streak occupies 2/3 instead of 1/3, the veins appear still darker and the contents more like wet sugar; that is, there will appear little globules or sediment.

Another static test is with the double prism and red light. A light being placed at fifteen or twenty feet should appear as three, two being seen by one eye and one by the other; the latter should be in the middle and all on a vertical line. If the middle one is out of line, the objects seen by each eye swinging to their respective sides, it proves weakness, no matter what the dynamic test showed; but if the objects swing to the opposite sides it is proof of spasm, no matter what the dynamic test showed. If the middle light deviates up or down, alone or in connection with the out or in turn, it simply means a complication in the nerve distribution, which always means rest. Of course this test is repeated after correction of error, and if the — indications are still present it increases the importance of the symptom with reference to the final prescription, and if the + impulse still remains it tells us we have not the full correction of eye error, and we increase it as indicated by the neurometer; if the up and down turn remains, it indicates rest and is a — symptom even if it appears in connection with the + symptom when the lights cross over.

SOME STATISTICS OF AMETROPIA.

Interesting Data Which Offer Suggestions to the Ambitious Practitioner.

As the two greatest faults among oculists and opticians are that they rarely get on enough + and often give too much — lenses, the following statistics are given just as they come from my files, and are the findings in 428 consecutive cases aggregating 856 eyes:

Simple hyperopia,	387,	or about	45 per cent.
Compound hyperopia,	287,	or about	33 per cent.
Simple hyperopic astigmatism,	44,	or about	5 per cent.
Simple myopia,	41,	or about	5 per cent.
Compound myopia,	32,	or about	4 per cent.
Simple myopic astigmatism,	7,	or about	1 per cent.
Mixed astigmatism,	58,	or about	7 per cent.

Exactly 50 per cent were astigmatic. Of these 428 eyes there were, of

Simple hyperopic astigmatism,	44,	or about	10½ per cent.
Compound hyperopic astigma'm,	287,	or about	67 per cent.
Simple myopic astigmatism	7,	or about	1½ per cent.
Compound myopic astigmatism	32,	or about	7½ per cent.
Mixed astigmatism,	58,	or about	13½ per cent.

In nearly all cases there was the so-called muscular imbalance, which disappeared soon after the correction of the errors; some at once. Of course, in addition to correcting the eyes, rest and regulation of habits was required for the worst cases. About 80 per cent showed exophoria (the other fellow called it esophoria), and the rest were either orthophoric or exhibited esophoria (the other's exophoria).

Of 161 pairs of + spheres prescribed, 27 were weaker than + 1.00; 85 were + 1.00 to + 1.75; 35 were + 2.00 to + 2.75; 8 were + 3.00 to + 4.00; 6 were + 4.00 to + 11.00. Of these 161 persons, 25 were anisometropes.

In 18 pairs of — spheres 2 were — .50; 1 — 2.50; 2 — 3.50; 1 — 4.00; 2 — 5.00; and 10 were anisometropes.

In 37 cases of oblique hyperopic astigmatism 25 required + compounds for both eyes; 11 required 1 + compound and 1 sphere; and 1 took 1 + compound and 1 cylinder. Of those needing a sphere for one eye, 6 were on the left, and 5 on the right.

In 8 cases of oblique myopic astigmatism 4 required — compound for both eyes; 3 took — compound and — sphere; 1 took — compound and — cylinder.

There were 4 cases of simple hyperopic astigmatism with oblique axes.

In 19 cases of mixed astigmatism with oblique axes 11 required compound for both eyes; 4 took 1 compound and + sphere; 4 took 1 compound and 1 + cylinder.

In 133 cases of compound hyperopia axes 90 or 180, 92 required compound for both eyes; 34 took 1 compound and + sphere; 7 took 1 compound and 1 cylinder. Of those requiring spheres for one eye 18 need it on the left and 16 on the right.

In 14 cases of compound myopia axes 90 or 180, 6 required compounds for both eyes; 6 used a — sphere in one eye; 2 used + sphere in one eye.

In 12 cases of simple hyperopic astigmatism 9 required cylinders for both eyes; 3 took + spheres in one eye.

In 18 cases of mixed astigmatism axes 90 or 180, 10 required compound for both eyes; 5 took 1 compound and 1 + sphere; 2 took 1 compound and 1 + cylinder; 1 took 1 compound and 1 — cylinder.

Of the 428 cases, 20 were boys under sixteen years; 82 were girls under twenty; 155 were women; 171 were men.

CYCLOPLEGICS, MYDRIATICS, MYOTICS.

Something About Drugs for Which the Neurologist Has, Occasionally, a Little Use.

Cycloplegics are drugs which dilate the pupils of the eyes and break down spasm of the ciliary nerves. Mydriatics are those which only dilate the pupils. Those commonly used are: (1), Atropine, an alkaloid of Atropa-Belladonna, or Deadly Night-shade; (2), Homatropine, a product of Atropine; (3), Duboisine, from Duboisia Myoporoides; (4), Hyoscamine, or Scopolomine, from Scopolia Japonica; (5), Daturine, from Daturia Stramonium; (6), Gelsemine, from Gelsemium Sempervirens; (7), Cocaine, from Erythroxlyin Coco.

Those in most common use are Atropia-sulphate and Scopolamine. They are often used in solution of 2 to 4 per cent. The objections to their use are: (1), the length of time required to secure complete mydriasis; (2), the discomfort to the patient from the effect on the general system which it enters via the tear-duct through the nose and throat; (3), it does not keep longer than a couple of weeks; (4), the dose is unavoidably inaccurate as to strength.

Homatropine, combined with Cocaine, and put up in gelatin disks, is the most satisfactory of all because (1), the accuracy of the dose; (2), it keeps indefinitely; (3), it acts quickly; (4), there is absolutely no danger in its use.

The disks, as put up by chemists, and kept by all wholesale drug and optical houses, are in bone boxes or glass bottles, each containing fifty disks.. The stock numbers of the ones most used are:

No. 338 Homatropine and Cocaine, 1/50 grain of each in each disk. One disk in each eye, under the upper lid (which should be everted and the disk placed on the conjunctiva, so it will be above the apex of the cornea), will smart slightly for a few moments, during which time the eyes should be kept

closed; after twenty minutes the pupils will dilate, and in about one hour the patient should be unable to read ordinary print at any distance, but it does not totally paralyze the accommodation as I have shown elsewhere in this book. The effects pass away in about twelve to twenty-four hours, and there are none of the after-effects which are so common in the use of the solutions.

No. 336 Homatropine 1/500 grain, is used as the other; dilates the pupil for ophthalmoscope examinations, and may be used on old people to enable the physician to examine cataracts in order to ascertain their condition.

No. 323 cocaine muriate, is a local anesthetic, used to deaden the conjunctiva while foreign bodies imbedded therein are removed. Takes effect in about six minutes, and passes off in about twenty minutes; dilates pupil for several hours. As soon as smarting ceases after inserting, go to work on the object.

Myotics produce artificial stimulation to the sphincter muscles. Those most used are Eserine, Calabarine and Physostigmine, all Alkaloids of Calabar Bean.

No. 331 Eserine 1/1000 grain to the disk is used as the others, except for the opposite effect. In some instances of irititis with spasm of accommodation there is danger of the iris adhering to the lens, and if it does, Atropine is used to pull it loose alternating it with Esrine to prevent mutilation of the membranes. Again, in myosis, or enlarged pupil from inaction the sphincter muscles of the iris, Eserine is used in the effort to stimulate it to action.

They are worthless except in tonic spasm where there is danger of adhesion of iris and lens, or where the cocaine is necessary to permit the removal of foreign bodies. I have never had occasion to use a myotic.

COLOR IGNORANCE AND BLINDNESS.

The First Named Is Very Common, While the Other Is Exceedingly Rare.

A practical test of color perception is to ask a great many people to name the color nearest white and keep a record of the replies. It will be found that men and boys know very little of colors and tints, while women and girls are usually well-informed; but even among the latter will be found many who insist that pale yellow or cream-color is the nearest white, when the fact is pale green is correct, because green is the central color of a spectrum; pale blue is below it and pale yellow above, if the prism which separates the elements is base down. Pale blue is where the lower dominates and pale green is where the central color prevails, hence the difficulty in distinguishing between the two.

No test for color-blindness is complete until a persistent effort to educate the subject fails. Of course there are cases so well-defined that it would be safe to bet they could not be educated, but I have seen such who learned readily after correction of errors in their dioptric systems. That there are genuine cases of absolute color-blindness has been proved abundantly, and of course the phenomenon calls for explanation. The old propositions that the rods and cones of the retina have to do with it by possessing three sets of color-perceiving elements, red, green, and blue or violet, and that there exist three different visual substances, red-green, blue-yellow and white-black appear fallacious to me because I am sure the consciousness of vision is not in the retina any more than it is in the cornea or lens, because the so-called dioptric system simply causes an image to be formed on the retina which transmits the impressions to the brain much after the

same fashion a counting machine registers on paper in its interior the effects of pressing on external keys.

In the physical portion of this work I have shown how an aplanatic lens is constructed and how the combination overcomes chromatic and spherical aberrations. Natural philosophy teaches that there is nothing artificial that has no original in Nature, therefore in looking about for the original aplanatic lens we find it in the crystalline humor of the eye; while its structure is liquid it is striated, like an onion, beginning with a bi-convex nucleus it is completed with negative menisci, the whole forming a bi-convex lens enclosed between the anterior and posterior capsules. As the artificial product accomplishes certain things, it is reasonable to conclude Nature made the crystalline in the same manner for the same purpose. I hold, therefore, that absolute color-blindness is due to the mal-structure of the crystalline.

One may be absolutely color-blind from abnormal index of dispersion in the lens, yet have no errors of refraction, but vision could not be normal because of the dispersion.

Other evidence that color perception is a part of the sensory nervous functions is that many blind people have shown their ability to distinguish color by touch. I once knew a man in Natchez, Miss., whose eye-balls had been enucleated when a child, who could, and often did, tell the color of different roses by touching them so lightly the petals were not injured. He could also tell the color of one's hair in the same manner. Others have reported similar cases.

One of the most delicate corroborations of my duality discoveries is in this color sense. On five pages following will be found the same figure printed in different colors. The figures are set well toward the top so the space below can be used for the transfer. To try the experiment there must be good daylight and by fixing the eyes steadily on the eye of the figure for a minute or two, then fixing on the center of the open space below, the complementary color, or duality, will manifest itself. If the figure observed is,

Black, white will appear.
Red, green will appear.
Green, red will appear.
Yellow, violet will appear.
Violet, yellow will appear.

And if the figure be in white on a black surface, black would appear when the transfer of the gaze occurred.

It will be found some people note these changes quicker than others, the complementary color often appearing as a border around the figure as the eyes fix on it. Those who are unable to see the change at all, even after repeated trials, day after day, have evidenced that their color perception is not normal. But that is not remarkable any more than it is that many people cannot learn music or other refined arts requiring delicate sensory apparatus.

In applying the principles upon which I have pursued my studies, the following solution of color dualities presents itself:

All laws, or causes, are accompanied. or succeeded, by effects. White is a combination of all colors; black is the absence of color. One is positive, the other negative in nature. In the spectrum, we have red, orange, yellow, green, blue, indigo and violet as the "seven elementary colors" of accepted authorities. The red is a decided element, while the orange and yellow are similar, green and blue are in the same relation, practically, as are also indigo and violet; therefore in red and yellow we have the +, or acute, elements, and in green and violet we find the —, or benign, elements. Of the +, red is the extreme and of the — violet is. In all positive chemical compounds the major portion being + dominates the minor portion which is —, and in all negative combinations the major portion being — dominates the minor portion of +, hence in the departures from perfect combinations, which would form white, if the major or + portion is red, the minor or — portion would have to be green, and if the major portion is yellow the minor portion would, necessarily, be violet. Then it follows, as a matter of course, that reversing the pro-

portions of elements would reverse the positions of the principals. The extreme + element combines with the least — and the extreme — combines with the least +, qualitatively, and which is to dominate in any combination is a matter to be settled quantitatively.

The complementary relation between color and sound is illustrated by the red scream of a frightened child and the black roar of thunder.

That the senses of smell and sound are complementary has been proved in the great perfumery houses of Detroit, where they have what they call the gamut of odors, regular musical staves, treble and bass, on which, instead of notes, are written the names of odors. A pianist improvises a sweet little melody and when the odors corresponding to the notes are combined in the same proportions the decoction smells as it sounded when it came from the piano. I mention this here, out of place, because I have no other place for it and it is a fact worth investigating, particularly by those whose esthetic tastes are already highly cultivated; it would be tedious to others.

PREFIXES AND SUFFIXES

PREFIXES.

A-, or an-, or am-, means the same as un-, in-, or im-.
Ana-, up, through, again.
Ant-, or anti-, against, or opposite to.
Apo-, from.
Bi-, two.
Contra-, against.
Dia-, through.
Dys-, difficult, painful, defective.
Ec-, ecto-, or ex-, away from, outside.
Em-, en-, in.
Endo-, ento-, internal.
Entero-, intestine.
Epi-, upon, over.
Extra-, outside.
Gastro-, the stomach.
Haema-, haemo-, or haemeto-, blood.
Hemi-, half.
Hetera-, abnormal.
Hydro-, water.
Hyper-, over, above, beyond.
Hypo-, below.
Hyster-, relating to the womb.
Im, in-, negative, as impossible or involuntary; it sometimes means within.
Infra-, beneath.
Inter-, between.
Intra-, inside.
Leuco-, white.
Lith-, relating to stone.
Macro-, large, to see with naked eye.
Melano-, pigmentation.
Meso-, middle.
Meta-, after.
Micro-, small, not visible to naked eye.
Mon-, single.
Multi-, Many.
Myelo-, referring to brain or spinal cord.
Myo-, muscle.
Neuro-, nerve.
Odonto-, teeth.
Oligo-, lack of.
Ophthalmo-, eye.
Osteo-, bone.
Oxy-, oxygen or acidity
Para-, through or near.
Peri-, around.
Poly-, many.
Pro-, for, before.
Pseudo-, false.
Pyo-, pus.
Pyr-, or pyro-, fire, inflammation, fever.
Retro-, backward, behind.
Sub-, under.
Super-, or supra-, above.
Sym-, or syn-, together, the same.

SUFFIXES.

-aemia, condition of blood.
-agogue, to carry away.
-agra, an attack.
-algia, pain.
-cele, a hernia or protrusion, tumorous.
-ectomy, to cut.
-graph, to write.
-itis, inflammation.
-logy, discourse.
-malacia, soft.
-mania, madness.
-odynia, pain.
-oid, form.
-oma, tumor.
-opia, relating to condition of eye.
-pathy, relating to diseases and their cure.
-phobia, fear.
-plasty, to form.
-raphy, a suture.
-rhagia, to burst forth.
-rhoea, to flow.
-scopy, to see.
-tomy, to cut.
-uria, referring to urine.

GLOSSARY

Aberration—Departure from normal.
Absorption—To take up.
Acetabulum—The cavity that receives the thigh bone.
Achromatic—Without color.
Achromatopsia—Total color-blindness.
Albinism—Absence of the layer of pigmentum nigrum .in optic choroid.
Anaemia—A condition of wasting.
Anchylobelpharon —.A stiffening of the eye-lids.
Aneurism—A wart-like dilatation of vessels.
Anisometropia — Unequal vision in one's two eyes.
Anopsia—Without vision.
Amaurosis—Obscure vision.
Amblyopia—See Amaurosis.
Ametropia — Imperfect .refractive condition of the eye.
Aphakia.— Absence of crystalline lens.
Aplanatic—Corrected rectilinearly.
Apparent—Something seen.
Approximate—Nearly.
Arcus Senilis—Senile ulcer, degeneration of corneal cells forming gray crescent or circle at edge of cornea, mostly in old people; harmless.
Astigmatism — Without a point. Caused by irregularity of the curvature or the refracting media.
Asthenopia — Fatigue of ocular nerves, neurasthenia.
Atrophy—Loss of vitality, wasting.
Biliary—Referring to the liver.
Binocular—Two-fold vision. To see with both eyes at once.
Blepharitis — Inflammation .of the eyelids.
Bulimia —.Morbid hunger. Occurs after eating too much; is, in fact, nature calling for help to digest what is in the stomach..
Canthi (s, canthus)—Angles formed by the upper and lower eyelids, from the middle to either side.
Combination—A union of parts.
Centripetal—Tending toward a center.
Centrifugal—Tending from a center.
Convergent—Two or more lines inclined toward a point.
Chromatic—Pertaining to colors.
Conjugate—Yoked together.
Cylindrical—Like a cylinder.
Catoptrics.— Laws of reflection of light.
Chalazion—Tumor of the eyelid.
Chromatopsia—Abnormal color sense.

Cilia—The eyelashes.

Ciliary Body—Apparatus of accommodation.

Collyrium—An eye-wash.

Coloboma—A mutilation.

Conjunctiva—To join together. The transparent membrane which lines the lids and covers the front of the eyeball.

Conjunctivitis—Inflammation of conjunctiva.

Corectopia—Pupil out of place.

Coredialysis—A rupture of the iris.

Cornea—Horny — The projection on the front of the globe.

Cyclitis—Inflammation of the ciliary body.

Cycloplegia—Paralysis of the ciliary muscles.

Cycloplegics—Drugs which paralyze the accommodations.

Disintegration—Separating parts.

Divergent—Two or more lines radiating from a point.

Dispersion—To scatter.

Density—Compact.

Diaphanous—Transparent.

Duality—Double.

Dacro-cystitis—Inflammation of the lachrymal sac.

Daltonism—Color-blindness.

Dioptre—To see through— a unit of measure in optics; one metre.

Diplopia—Double vision.

Dynamic—Force.

Ecchymosis—Black eye.

Ectopia—Partial luxation of the crystalline.

Ectropion—Eversion of eyelids.

Emmetropia—A perfect condition of the refracting media.

Embolism—A plugging.

Entropion—Inversion of eyelids.

Entozoa — A worm-like parasite, which finds its way into almost any portion of the eye, and destroys tissue by causing small cysts.

Enucleate—To remove.

Epiphora—Overflow of tears.

Esophoria—Convergence of visual axes.

Essential—Necessary.

Equivalent—Equal in value.

Exophoria — Divergence of visual axes.

Exophthalmos — Abnormal prominence of eyeballs. Grave's disease.

Foramen—A passage or opening.

Fossa—A ditch.

Fundus—Bottom.

Finite—Having a limit.

Formula—A form.

Glaucoma—Green; a disease of the ciliary processes and optic nerve.

Glioma—Glue.

Hypothesis—A supposition assumed for the purpose of presenting an argument.

Horizontal—From horizon to horizon.

Hemiopia—Half vision.
Hemeralopia—Day blindness.
Heterophoria—An abnormal muscular condition.
Heterophthalmos—Congenital differences of color in the iris, or of two eyes.
Hippus—Alternate contraction and expansion of pupil.
Hordeolus—A style.
Horopter—The field of vision included by both eyes at once, without moving.
Hyaloid—Glass-like; a thin membrane which lines the inner surface of the eye.
Hyalitis—Inflammation of the vitreous.
Hyperphoria—One optical axis tends above the other.
Hypopyon—An abscess from corneal ulcers.
Inverted—Upside down.
Index—A pointer.
Iridectomy—A cutting of the iris.
Iridodialysis—Separation of iris from ciliary body, as a result of blows.
Iridodonesis—Trembling of the i
Iris (a rainbow)—The colored portion of the eye surrounding the pupil.
Iritis—Inflammation of the iris.
Jugular—Pertaining to the throat.
Jurisprudence—Relating to law.
Keratitis.—Inflammation of the cornea.
Keratokonus—Conical shape of the cornea.
Keratonyxis—Puncture of the cornea.
Luminous—Emitting light.
Leucoma—White.
Leucorrhoea—White, to flow.
Lagophalmos—Inability to close the eyelids.
Locomotor Ataxia — Creeping paralysis.
Metaphysics — Pertaining to the mind. After physics.
Meridian—A line drawn from one side of a circle to the other through the center.
Meter—Measure.
Macula—Spot. The field of sharpest vision.
Malingerer—One who falsely pretends to have an incurable defect of vision, or other function, to excite sympathy or evade duty.
Metamorphopsia—Distorted vision.
Migraime—Sick headache.
Muscae Volitantes—Floating specks in the eye.
Mydriatics—Drugs which dilate the pupils.
Myopia—To close the eye.
Myotics—Drugs which stimulate the accommodation.
Neurology—The science which treats of the nervous system.
Negative—Opposed to positive.
Nodal Point—A center of curvature.

Nebula—A cloud.
Nephritis—Inflammation of kidneys.
Neuritis—Inflammation of the optic nerve.
Nictitation—To wink.
Nystagmus—A jerking of the eyeballs.
Nyctalopia—Night blindness.
Oblique—Slanting.
Oedema—An exudation.
Ophthalmia — Inflammation of the eyes.
Ora Serrata — Serrated boundary. The circle of connection between the retina and ciliary processes.
Orthophoria—Normal muscular conditions.
Ophthalmology—The science which treats of the eyes.
Ophthalmoplegia (interna and externa)—Paralysis of the sphincter muscles of pupils and ciliary; usually from the use of cycloplegics.
Parallel—Two lines constantly at equal distance from each other.
Perpendicular—At right angles to.
Positive—Absolute, direct.
Physics—Natural philosophy.
Plano—Flat.
Palpebrae—The eyelids.
Pannus — Corneal vascularization from long continued irritation.
Papilla—A nipple. The optic disk.
Phakatis—Inflammation of the lens.
Phlyctenule—A pimple.
Photophobia—Aversion to light.
Pinguecula—A small elevation on the ocular conjunctiva; sometimes mistaken for pterygium.
Posterior Synechia—Adhesion of iris to lens.
Presbyopia—Old sight.
Pterygium—A little wing. Is a hypertrophy of the conjunctiva and grows on sclerotic and cornea, sometimes interfering with vision. May be removed.
Ptosis—A falling of the upper lid from weakness of the third nerve.
Retina—A net. The visual membrane of the eye.
Repulsion—To drive away.
Refraction—To break.
Reflection—To turn back.
Right Angle—Perpendicular.
Respective—With reference to.
Reversed—Turned around.
Spectral—Refers to colors found by separation of a ray of light into its elementary colors by a prism.
Symbol—Having resemblance.
Spherical—Like a sphere or globe.
Segment—A slice.
Sclerosis—Hardening.
Sclerotic—Hard. The white of the eye.
Scotoma —. Obstruction. of .vision from hemorrhages. Darkness.
Strabismus—To squint.
Stroma—Bedding.

Staphyloma—A bulging projection. Anterior, comes after corneal ulcers, and is a bluish-white in appearance. Posterior, is a projecting backward of the posterior pole of the eye.

Supercilium—The eyebrows.

Symblepharon—Adhesion of ocular and palpebral conjunctiva, caused by escharotics, such as lime, ashes or other alkalies.

Synechia—To hold together.

Synchisis—To flow together.

Transparent—Passes light so objects can be seen.

Translucent—Passes light, but objects cannot be seen.

Tapetum—A carpet.

Tension—The condition of an organ, muscle or nerve when under strain.

Thrombosis—A plugging of retinal vessels by blood clots. Sometimes causes hemorrhages which bring at least temporary blindness.

Trachoma—(Rough). Granular conjunctivitis.

Trauma—A wound.

Tinea Tarsi—Eczema of border of lids.

Urea—The chief solid constituent of urine.

Uveal Tract—The choroid, iris and ciliary body of the eye.

Vertical—Straight up and down.

Virtual—Existing in effect.

Vesicular—Bladder-like.

Vascular—Pertaining to vessels.

Vitreous—Glass-like.

Xanthelasma — Yellow patches of fibrous tissue on the lids, mostly of women. Harmless, but may be removed.

Xerophthalmus—Dry eye.

"Neurology and Metaphysics"

By Charles McCormick, M. D.

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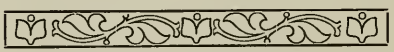

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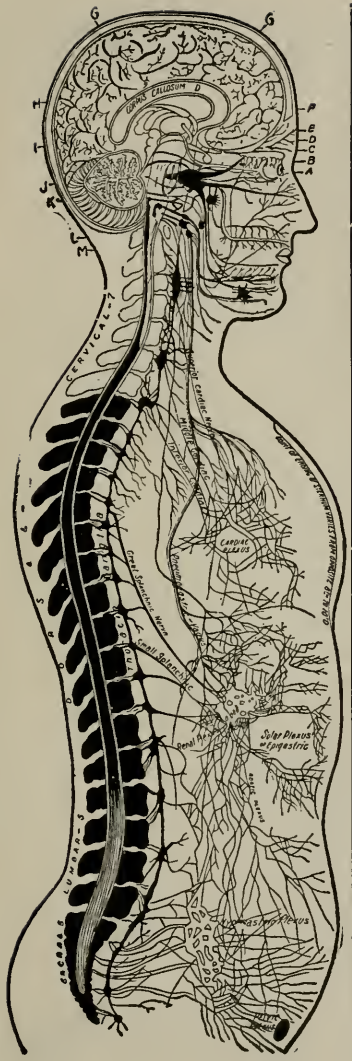

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"protection"

at the Public's Expense

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